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ABSTRACT

Basic water-related concepts and underlying principles of acid rain are described in this curriculum in a manner that young children can understand. The curriculum consists of activities presented in four units: Background Unit, Earth Science Unit, Life Science Unit, and Extension Unit. The first three units consist of several modules, each module containing a teacher-directed introductory activity followed by two or more laboratory blocks (consisting of several student activities). The introductory activity is a discrepant event or open-ended in nature to encourage students' questions and to motivate them to further inquiry in the activities included in the laboratory blocks. A transition section (or focus) is included between each laboratory block, tying in concepts explored earlier to those concepts which follow. Materials needed and instructional strategies are noted for each activity. Topics covered include the nature of water, clean/dirty water, acids/bases, water cycle, Minnesota's glacial past, acids and rocks, stream tables, ecosystems, and acids and brine shrimp. Field trip activities are included in the Life Science Unit. The Extension Unit includes an acid rain game and various activities (including a simulation) related to use of the Boundary Water Canoe Area in northern Minnesota. Student materials for this unit are provided. (Author/JN)

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AQUATIC ACTIVITIES

FOR MIDDLE SCHOOL CHILDREN

A Focus on the Effects of Acid Precipitation

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Dr. Donald McNaught, Director, Minnesota Sea Grant

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Some of the activities in this unit have been adapted from several sources including:

Elementary Science Study (ESS), and

Science Curriculum Improvement Study (SCIS).

In addition, permission has been granted to reprint the following specific activities:

Acids and Metals, adapted from Easy Experiments with Water Pollution, by Harry Sootin, Four Winds Press, New York, Copyright 1974.

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INTRODUCTION

The Great Lakes states of the Upper Midwest are generally characterized by an abundance of water. Whether that water be from the Great Lakes, the largest contiguous freshwater body in the world, or from inland lakes, or from the large Upper Midwest water table, water is an important resource to residents of this region. Protection of this valuable resource requires citizens who are knowledgeable about water and the threats to water quality. Even the youngest students can begin to appreciate this life-sustaining resource, and their role in its protection.

Acid precipitation has become a threat to much of the freshwater in the Upper Midwest as well as many other parts of the United States, Canada, and Scandanavia. Formed from industrial and automobile pollutants, acid precipitation has the capability of rendering a lake barren of fish. The basic underlying principles of acid rain are described in this curriculum in a manner that young children can understand.

FORMAT

There are several KEY CONCEPTS for each module in each of the four units. An ACTIVITY BLOCK with MAIN IDEAS is developed for each KEY CONCEPT. All modules have a teacher directed INTRODUCTORY ACTIVITY which is a discrepant event or open-ended in nature to encourage student questions and to motivate them to further inquiry in the activities to follow.

MATERIALS and the necessary ADVANCED PREPARATION are noted for every ACTIVITY BLOCK which may include anywhere from one to six activities.

A transition section, or FOCUS, is included between each Activity Block. This consists of a PARAPHRASE or the concepts and/or activities explored earlier and how they relate with the next set of activities/ concepts, and a QUESTION to lead the students in an inquiry mode into the next Activity Block.

Although a specific FOCUS for each ACTIVITY BLOCK is provided, teachers are encouraged to adapt them to their particular class and to make up their own FOCUS statements between the individual activities as well.

Specific direction for setting up each activity are included under PROCEDURE. EXTENSION activities are suggested to give some ideas to teachers who might want to develop the Activity Block or Module further.

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BACKGROUND

UNIT

WATER, WATER EVERYWHERE

MODULE OVERVIEW:

In this module, student hands-on activities will focus on questions related to the various properties of water such as surface tension, expansion when freezing, and the buoyant property of water which allows many objects to float. Allow students' interests and questions to guide you in the selection of appropriate activities and don't feel limited to the activities here. These activities will probably cause children to generate more questions that can lead them into designing their own experiments.

APPROXIMATE TIME: 6-7 class periods

KEY CONCEPTS OF THE MODULE:

A. Water has a strong tendency to stick to itself (surface tension).

B. When water freezes into ice, it expands, becomes less dense, and thus can float on water.

C. The ability of an object to float in water depends upon how much water it is able to displace (push aside).

MATERIALS NEEDED FOR THE MODULE:

For each student group: clear plastic drinking glasses, eyedropper, large plastic containers, paper clips, water, corn syrup, rubbing alcohol, liquid dish soap, copper wire, waxed paper, aluminum foil, paper toweling, screw lid glass jar (e.g., baby food jars), plastic sandwich bag, ice cubes, wooden blocks (4" x 4" x 1/2"), bucket, pill bottle, rubber bands, cans of different sizes, rulers, plasticene (oil-based clay), rulers, and soap flakes.

INTRODUCTORY ACTIVITY

MATERIALS:

Clear plastic container, eyedroppers, empty plastic containers, paper clips, water.

PREPARATION SUGGESTION:

Provide each student group with eyedroppers, a clear container filled with water, and several empty containers, and various objects such as paper clips. You will also want to have a good supply of paper towels on hand.

PROCEDURE:

Divide the students into groups of three. Provide each group with the materials mentioned above and then structure their group work by relating to them the following story:

"While walking home from school one afternoon, you meet a visitor from another planet. He asks you to explain to him what this strange stuff called 'water' is. Each group is to list as many things as they can think of about water to tell this visitor. I've provided some water to help give you some ideas."

EXTENSION:

Each student group could also be asked to choose their best 3 observations about water and incorporate them in a cartoon-type picture of their meeting with the strange visitor. They could have fun imagining what he might look like and the cartoons could then be put up in the room along with their lists.

ACTIVITY BLOCK A--WHAT CAUSES WATER TO STICK TO ITSELF?

MAIN IDEAS:

1. Water has a high surface tension (tendency to stick to itself).
2. Impurities in water affect this tendency to stick to itself.

MATERIALS:

Water, corn syrup, rubbing alcohol, liquid dish soap, clear containers for the liquids (about 1 pint), copper wire, waxed paper, aluminum foil, clear plastic cups/glasses, paper toweling.

PREPARATION SUGGESTIONS:

Obtain the above materials and student groups can set up the activities themselves.

FOCUS:

Paraphrase: "Yesterday you imagined what it would be like to tell a strange visitor from another planet everything you knew about water. You made lists of the different properties of water that you have observed or could think of. The next few activities you are going to do will help you observe and learn even more about water and its different properties."

Question: "What can you tell the strange visitor about water drops and the 'stickiness' or 'grabbiness' of water?" (More specific questions should be given as part of the focus before each activity and as part of the different task statements.)

ACTIVITY 1

MAIN IDEA:

The surface tension of a liquid can be observed by the shape that a drop of liquid takes.

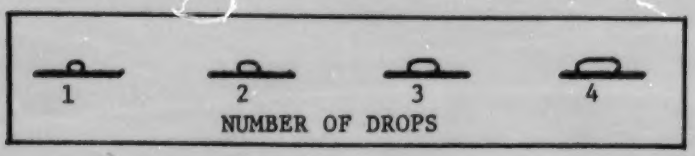
PROCEDURE:

Provide the student groups with eyedroppers, containers of water, pieces of waxed paper, aluminum foil, and paper toweling.

The following questions can be used to stimulate the student's exploration of the shape of water drops.

1. What can you find out about the shape of water drops?
2. What happens when you add more drops?
3. What happens when two drops collide?
4. What happens when you put the drop on waxed paper over some writing?
5. What happens if you put an air bubble in the drop?

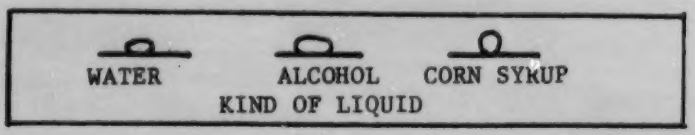
Have them make sketches of the drops and a sequence of sketches (of 1 to 5 drops)



ACTIVITY 2

MAIN IDEA:

Surface tension is a property of the liquid and will be different for different liquids.



PROCEDURE:

Provide the student groups with eyedroppers, waxed paper and the following liquids: water, corn syrup, rubbing alcohol, and liquid dish soap.

Ask the students, "What can you find out about the shape of the drops for these liquids?"

ACTIVITY 3

MAIN IDEA:

Since water tends to stick to itself, a glass can be filled higher than its rim without overflowing.

PROCEDURE:

Provide the student groups with water, an empty glass, a container to catch spilled water, and an eyedropper.

Ask the students the following questions: "How much water can you put into the glass without spilling over?" (If the students have filled the container carefully, they should be able to observe, by viewing the glass from the side, that the water extends over the top of the glass.)

ACTIVITY 4

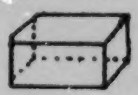
MAIN IDEA:

Soap bubbles form because the surface of the liquid acts like a skin.

PROCEDURE:

Provide the student groups with a thick soap solution (prepared by placing 4 tsp. of soap flakes, such as Fels naphtha, in 4 cups of hot water and letting stand for 4 days), and several pieces of copper wire (or paper clips can be used for smaller bubbles).

Ask the students: "How many different ways can you think of to make soap bubbles?" In your instructions, encourage the students to experiment with all sorts of different shapes (3-dimensional wire forms made simply by bending wire will give excellent soap bubbles).



EXTENSION:

MATERIALS:

Large cake pan (8" x 14"), dish soap, plastic straws, twine.

PROCEDURE:

Large soap bubbles can be made by threading two straws onto a large piece of twine. Tie the twine into a loop (see diagram).

Make a soap solution by mixing the dishsoap with water. Place the bubble maker into the soap solution. Pull the bubble maker quickly up and out of the solution and, at the same time, bring the two straws together to form a bubble.

How big can you make the bubble?

Can you catch a bubble? (Which works best--wet hands or dry hands?)

-What colors do you see in the bubble?

ACTIVITY BLOCK B--WHAT HAPPENS WHEN WATER FREEZES?

MAIN IDEA:

1. When water freezes, it expands.
2. Water expands upon freezing and the resulting ice will float.

MATERIALS:

Screw lid glass jar (students should bring these from home), plastic cups, water, plastic bag, ice cubes.

FOCUS:

Paraphrase: "In the last series of activities we discovered one property of water--that is, how 'sticky' or 'grabby' water is. Water has some other special properties when it freezes, and in the next activities we are going to discover at least two of those."

Question: "What happens to water if we put it in a jar and allow it to freeze?"

ACTIVITY 1

MAIN IDEA:

When water freezes, it expands.

PROCEDURE:

Fill an old, screw-lid glass jar or bottle with water and tightly fasten on the lid. Ask the students to predict what will happen if you put the jar in the freezer.

Place the jar in a plastic bag and seal it. Place the bag in the freezer (or outside if it is below freezing) for 24 hours and then bring in the bag.

Discuss with the student the reason why the bottle broke. Ask students how the expanding of ice sometimes damages roads and sidewalks during the winter.

ACTIVITY 2

MAIN IDEA:

Ice will float.

PROCEDURE:

Provide the students with glasses of water and ice cubes.

The following questions can be used to stimulate the students' exploration of the properties of ice:

1. What happens to the ice when you put it in water?
2. About how much of the ice cube is above the water?
3. When water freezes on a lake, the ice is at the top. What would happen to fish if ice were heavier than water? (Fish would have to move to the top of lake and probably would have nothing to feed on.)

ACTIVITY BLOCK C--WHAT MAKES OBJECTS FLOAT?

MAIN IDEAS:

1. Floating objects can be made to sink by making them heavier.
2. Objects which sink can be made to float by spreading them out so that they displace more water.
3. Objects appear to be lighter (in weight) in water.

PREPARATION SUGGESTIONS:

You will need to obtain several wooden blocks (4" x 4" x 1/2"). If these are shellacked or varnished, they will last longer.

MATERIALS:

Buttons, ivory soap, washers, ping pong balls, cork, pieces of sponge, wooden blocks (4" x 4" x 1/2"), large containers or buckets, pill bottles, rubber bands, cans of different sizes, rulers, and plasticene (or oil based) clay.

FOCUS:

Paraphrase: "In the last two activities you learned how water expands when it freezes and floats. In the next few activities, you will be studying about whether objects float in water."

Question: "What makes objects float?"

ACTIVITY 1

MAIN IDEA:

Some objects will sink in water and some will float.

PROCEDURE:

Provide the student groups with a tray containing some or all of the following objects (or other objects of your choice, e.g., buttons, ivory soap, washers, ping pong balls, cork, pieces of sponge).

After students have made their predictions, provide them with a container of water to test the accuracy of their predictions.

A data sheet is provided on the next page. Students should use the top portion of the table (marked "predicted") to list under "sink" those objects which they predict will sink and under "float," those objects expected to float.

DATA TABLE

SINKERS AND FLOATERS

	SINK	FLOAT
PREDICTED		
OBSERVED		

ACTIVITY 2

MAIN IDEA:
Floating objects can be made to sink by making them heavier.

PROCEDURES:
Provide the student groups with containers of water (such as a plastic bucket). Give them several cans of different sizes.

The following questions can be used to stimulate the students' exploration of floating objects:

1. Which can is harder to push under the water? (Add water to the cans until they just sink to the rim.)
2. Which can needs the most weight to just sink it to the rim? (Provide the students with wooden blocks, 4" x 4" x 1/2".)
3. How much of the block floats under the water?
4. How can you make more of the block sink? (Pile on more blocks.)
5. What happens when you pile up several blocks? How much of the stack is under water?

ACTIVITY 3

MAIN IDEA:
Sinking objects can be made to float by spreading them out so that they displace more water.

PROCEDURE:
Provide the students with balls of oil based clay.

Challenge the groups to devise a way to make the clay float. (In order for an object to float, that object must displace a weight of water greater than the weight of the object. Since a cork is fairly light when compared to its volume it will displace a greater weight of water than it weighs itself. A nail, on the other hand, is relatively heavy for such a small size, so it will sink. These concepts of buoyancy, displacement, and density are difficult for elementary students to understand. It would be sufficient if the students could discover for themselves that a ball of clay that would sink can be made to float by spreading it out.) Tell the students to use the washers to see how many it takes to sink a boat made of clay. Allow them to try other materials such as tin foil or paper.

EXTENSION:
You may wish to extend this activity by pointing out how important this property of floating is to ships. The large oil tankers are designed so that when they are full they will be floating at the proper level. However, when they are empty and, therefore, lighter, they would have a tendency to float too high on the water and might be in danger of overturning. For that reason, the empty ships are often filled with sea water as "ballast" to make them heavier and hence safer.

ACTIVITY 4

MAIN IDEA:
Objects appear lighter (in weight) in water.

PROCEDURE:
Provide the students with pill bottles and rubber bands. Have students fill the pill bottles with water. Ask the groups if they can figure out a way to find out which bottles are heavier just using what they have available. (They can measure how far the rubber band stretches when attached to the pill bottle and lifted off the table. Students should be encouraged to use rulers to measure the length of the stretched rubber band.)

CULMINATING ACTIVITY
You may wish to return to the original situation of the visitor from outer space. Each group or individual student could now do some creative writing telling the story of their meeting with the strange creature. They could illustrate these stories and share them with the class and then put them up on display.

This might also be a good opportunity to direct interested students to a study of shipping on Lake Superior. Two free publications may be useful in this regard.

Great Lakes, Great Boats
Michigan Department of Natural Resources
Ann Arbor, Michigan

Our Great Lakes
Sea Grant Communications Office
1800 University Avenue
Madison, Wisconsin 53706

You may also wish to play "The Wreck of the Edmund Fitzgerald" by Gordon Lightfoot for the students.

CLEAN WATER--DIRTY WATER

MODULE OVERVIEW:

In this module, student experiments and activities will focus on "dirty" (polluted) water and how it can be "cleaned" (treated or purified).

APPROXIMATE TIME: 1 week

KEY CONCEPTS FOR THE UNIT:

A. Water can contain dissolved and suspended materials which will pollute it.
B. Many impurities can be removed from water.
C. Everyone should be concerned with keeping water clean.

MATERIALS NEEDED FOR THE MODULE:

Table salt, sugar, baking soda, sand, dirt, soap flakes, coffee, pieces of food, plastic spoons, baby food jars, magnifying lenses, small containers, fresh snow or rainwater, plastic bleach bottles, funnels, cotton, cheesecloth, gravel, old nylon stockings, burlap bags, cans with holes, paper toweling, water treatment maze handouts.

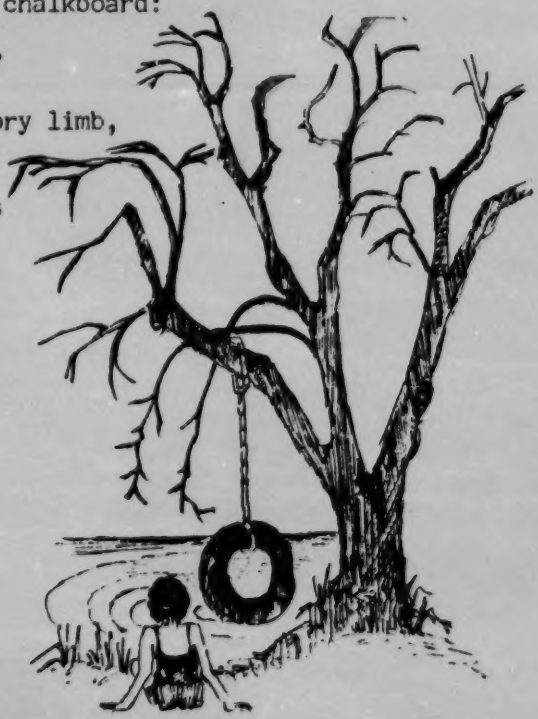
INTRODUCTORY ACTIVITY

PROCEDURE:

Write the following verse on the chalkboard:

Mother may I go out to swim?
Yes, my darling daughter.
Hang your clothes on a hickory limb,
But don't go near the water.

---Anonymous



Ask, "Why do you think the mother wouldn't let her daughter go into the water?" Students may say that she couldn't swim or that she had a cold or was sick. Hopefully, someone will mention that the water was dirty, but if they should use the word "polluted," take the opportunity to write it on the board and work out a definition with them. Try to get students to share some of their feelings about dirty (or polluted) water.

ACTIVITY BLOCK A - WHAT IS DIRTY WATER?

MAIN IDEAS:

1. Both seen (suspended) and unseen (dissolved) materials may be found contributing to pollution in water.
2. When a solution containing solids is evaporated, the solid particles remain.
3. Polluted water is often unpleasant in odor and appearance.

SAFETY CONSIDERATIONS:

Students should be instructed not to drink any of the liquids. The unpleasant smell is due to action of bacteria which can cause stomach problems if ingested.

PREPARATION SUGGESTIONS:

Obtain the necessary materials for each activity (enlist the help of students when possible or appropriate). Have students set up the activities.

ACTIVITY 1A

MAIN IDEA:

Solid pollutants of water may exist as suspended particles or dissolved substances. When you evaporate the solution, the solid particles remain.

MATERIALS:

Table salt, sugar, baking soda, sand, dirt, soap flakes (detergent), coffee, pieces of food, plastic spoons, plastic drinking glasses, baby food jars (for extension), and other substances you may decide to use.

FOCUS:

Paraphrase: In the next few experiments we will put different substances in water to see if they all "disappear" (so we can't see them in the water) to determine whether we can smell them or not.

Question: Which of the substances will dissolve ("disappear") in water?

PROCEDURE:

Provide each student group with plastic drinking glasses half filled with water and with an observation data sheet (see attached example to duplicate).

Ask the groups to predict which of the substances will dissolve and list their predictions in the upper portion of the table. Provide each group with plastic drinking glasses half filled with water and have students drop in a small amount (e.g., teaspoon) of the substances into the water. Stir the solutions with plastic spoons. Have students fill in Table 1 under observations in the lower portions of the table. Ask the students to compare what they predicted with what they observed. Tell the groups to label their glasses with the substances that they used and their names and save these for part 1C or the suggested EXTENSION activity.

ACTIVITY 1B

PROCEDURE:

Provide the groups with some other substances such as epsom salts, bath salts, and some mixtures (such as salt and sand). Ask them to predict which will dissolve based on what they learned in the last activity. Have each group record these predictions and check their predictions by dropping materials in the glasses and stirring them as in the previous activity.

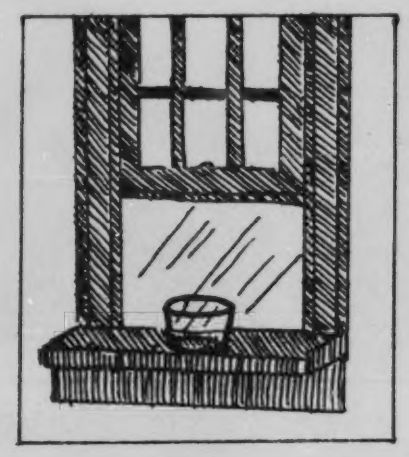
OBSERVATIONS

	THINGS WHICH CAN BE SEEN AFTER PUTTING THEM IN WATER.	THINGS WHICH CAN NOT BE SEEN AFTER PUTTING THEM IN WATER.
PREDICTED		
OBSERVED		

ACTIVITY 1C

PROCEDURE:

Remind the students that in the last activity some of the materials that they added to the water seemed to "disappear." Ask, "How can you find out if those things that you put in the water really disappeared or if they are still there?" Students may suggest several approaches, but perhaps the most useful is to evaporate the solution. (The solids will remain.) Label the glasses with the students' names and the contents of the glasses and place them on the windowsill in the sun. Leave the glasses until they have evaporated to dryness. In your follow-up discussions, discuss how there may be things in water that make it dirty but that we can't see or smell.



EXTENSION:

Provide the student groups with baby food jars half filled with water and various types of food. They might be asked to bring things from home to put into the water. Have them put the different kinds of food into each of the jars, label them, seal them and set them aside in the sunlight. They should check the jars every day and record observations concerning appearance and smell. Have a follow-up "What did you find out?" discussion.

ACTIVITY 2

MAIN IDEA:
Natural water contains dissolved impurities.

MATERIALS:
Magnifying lenses, small containers, fresh snow or rainwater.

PROCEDURE:
Ask the students, "Can you find out if rainwater or snow contains things that can't be seen?" Provide student groups with magnifying lenses, small containers and a quantity of freshly fallen rainwater or melted snow. Evaporate the rain or snow (use method described in Activity C) to see what was in it. Ask the students if they think that the materials in rain or snow are unhealthy for people (or whether they think that rain and snow can be "dirty").

ACTIVITY BLOCK B--HOW CAN WATER BE CLEANED?

MAIN IDEA:
Dirty water sometimes can be cleaned by sedimentation and filtration.

MATERIALS:
Variety of containers (or prepared plastic bleach bottles--see below), funnels, cotton, cheesecloth, sand, gravel, dirt, old nylon stockings, burlap bags, cans with holes in them, paper towels, and any other materials that you or the students might think of to clean the water.

TEACHER PREPARATION:

Bleach bottles make handy containers for filtering. Poke some holes in the lid, and using a sharp knife, cut the bottom off the bottle. The plastic bottle can then be filled with a variety of materials and the dirty water placed in the cut off end. These bottles will clean up easily and stack for storage.

FOCUS:

Paraphrase: You've done several experiments that showed you how water can be dirty (or polluted) even though sometimes you can't tell by looking at it or smelling it. When you evaporated the water/snow, you could see the polluting particles that had dissolved in the water and originally seemed to disappear. Now we're going to do some experiments to see how we might clean polluted/"dirty" water.

Question: How many ways can you find to make the water clear?

PROCEDURE:

Provide each group with a jar of muddy water. Challenge them to invent a way (or several ways) for cleaning up the water. Have the groups share their methods with each other in a follow-up discussion.

While the students are involved in this activity, take a jar of muddy water and set it aside. When the particles have begun to settle at the end of class, direct the students' attention to the fact that it looks less muddy. Shake it up again and have them predict what it will look like after sitting there overnight. When they observe it at the beginning of the next class period, you can have a discussion of what they found out. It is important to develop the concepts of filtration and sedimentation if the students are to understand the water treatment in Activity Block C.

ACTIVITY BLOCK C--HOW DO CITIES CLEAN UP DIRTY WATER?

MAIN IDEA:

Cities use many of these same techniques in their water treatment plants.

MATERIALS:

Water Treatment Mazes

PREPARATION SUGGESTIONS:

Contact your local water treatment plant to arrange a tour for your class. If that can't be arranged, it is possible that the treatment plant will have speakers that could come to your classroom.

FOCUS:

Paraphrase: We have seen how filtering dirty water and letting dirty water sit so that the dirt falls to the bottom are both ways of cleaning water. The water that you drink is clean. Your city uses these same methods for cleaning the water before it gets to your faucet.

Question: How do cities clean up dirty water?

PROCEDURE:

This would be a good time to explain the terms of FILTRATION and SEDIMENTATION if you haven't done so already. Tell the students that cities use these same methods to clean their water at a water treatment plant. Ask them if they can think of other ways that cities use to clean water (you might suggest the taste of water or swimming pools as a clue.) You should discuss two other methods, chlorination and aeration. Although it wasn't discussed in the above activities (because they would be difficult to do), chlorine as well as other chemicals are used to help purify water. In addition, water is aerated (air is bubbled through or else it is shot into the air like a fountain) both to improve the taste as well as to break down any remaining organic materials (by a process of oxidation).

Hand out the water treatment plant maze to do in order to give students some idea of what they should be looking for when they tour the Water Treatment Plant. In your discussion, encourage the students to explain how each step in the treatment plant has helped to clean the water.

EXTENSION:

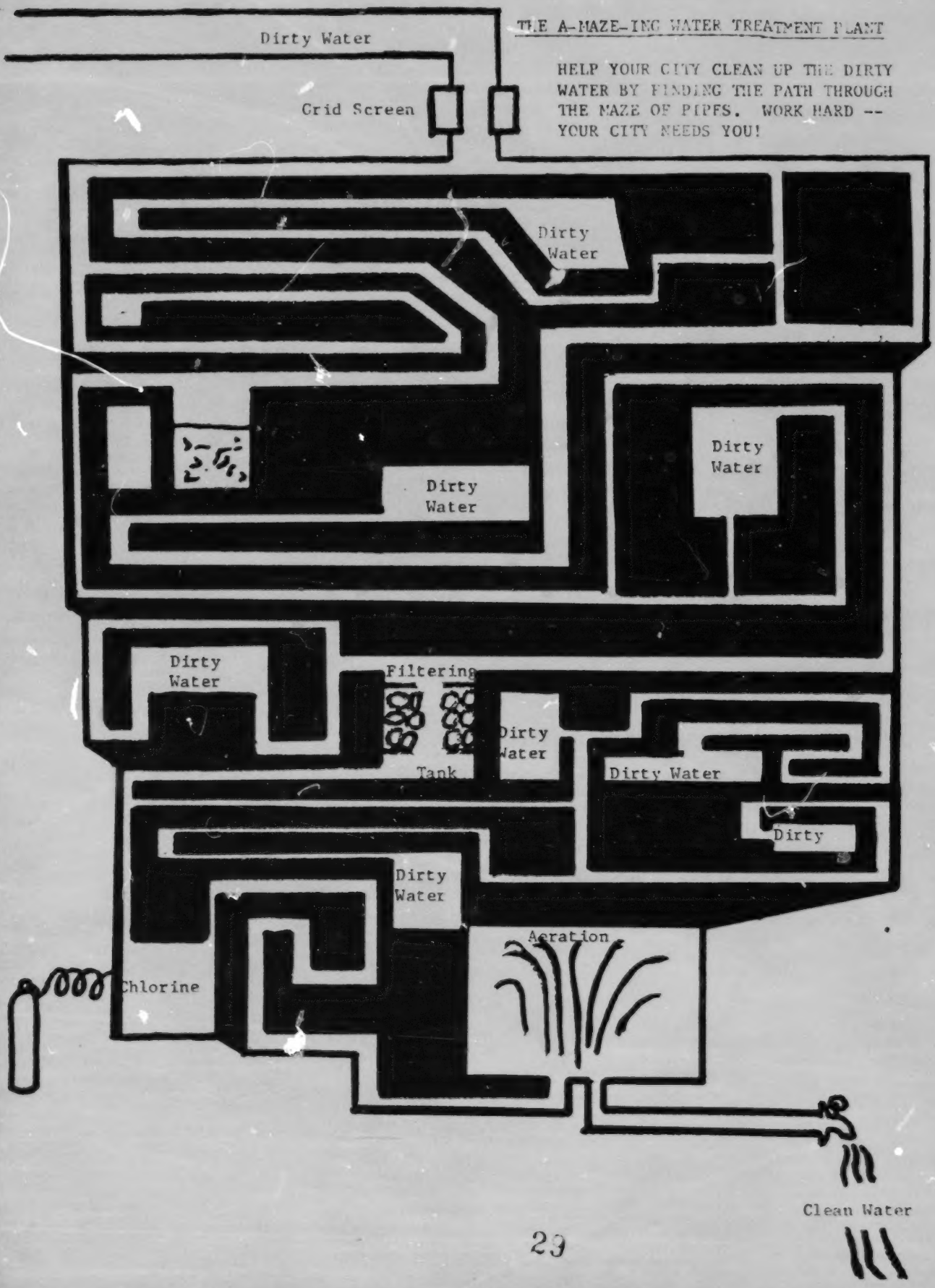
Encourage individual students or student groups to do some investigating to find out where their city water comes from. This would be a good mapping exercise. (Your local water department should be a good source of information.)

RELATED ACTIVITIES:

"The Jiffy Water Treatment Plant" and "The Dekro Water Treatment Plant" in Creative Sciencing by Alfred Devito and Gerald Krockover.

THE A-MAZE-ING WATER TREATMENT PLANT

HELP YOUR CITY CLEAN UP THE DIRTY WATER BY FINDING THE PATH THROUGH THE MAZE OF PIPES. WORK HARD -- YOUR CITY NEEDS YOU!



ACIDS AND BASES

MODULE OVERVIEW:

In this module, student hands-on activities will focus on acids and bases, and their indicators. After their experiments have given them a better understanding of what an acid is, they will be given some background information on acid rain so they can consider its environmental implications. An information packet on acid rain is included at the end of the module.

APPROXIMATE TIME: 1 week

KEY CONCEPTS OF THE MODULE:

A. Certain substances (such as the liquid from red cabbage leaves) can be used to identify acids and bases.

B. Acids are substances that, when added to water, turn certain substances (such as red cabbage water) a certain color; and bases are substances that when added to water turn certain substances (such as red cabbage water) a different color. When acids and bases are combined in the proper proportion, they form a neutral solution (neither acid nor base).

C. Acids can cause pollution (e.g., acid rain or acid run-off from mines).

MATERIALS NEEDED FOR THE MODULE:

Red cabbage, beaker or pan, heat source, small containers, samples of acids, bases and salts (see Activity Block B).

INTRODUCTORY ACTIVITY

PREPARATION SUGGESTIONS:

At least one hour before class, cut a red cabbage leaf into small pieces. Soak the cabbage leaves in very hot water (boiling, if possible). Also prepare three glasses by filling the first 1/3 full of water, the second 1/3 full of white vinegar, and the last glass 1/3 full of a solution made by dissolving 2 tablespoons of baking soda in a cup of water.

PROCEDURE:

Tell the students that you are going to put on a magic show. Set up the glasses with the water glass in the middle. Add several drops of the cabbage water ("Magic Purple Liquid") to the center water glass. Point out that the color is a light purple. Add the baking soda solution (this is a base). The color will now change to green. Finally, add the vinegar (this is an acid). The color will change to red (or pink).

This discrepant event should generate a lot of questions which should be recorded on the blackboard and/or on a large sheet of paper for future references.

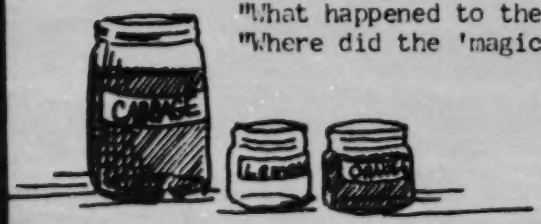
ACTIVITY BLOCK A--WHAT IS "MAGIC PURPLE LIQUID"?

MAIN IDEA:
The liquid from the red cabbage leaves can be used to identify acids and bases.

MATERIALS:
Red cabbage, beaker or pan for boiling, heat source.

FOCUS:
Paraphrase: We saw that there was a purple liquid that changed colors. Today we will see where that liquid comes from.
Questions: What can you find out about the Magic Purple Liquid? Where does the Magic Purple Liquid come from?

PROCEDURE:
Soak red cabbage leaves in very hot water for 1 hour. Give the students an opportunity to do some exploratory activities with the liquid for awhile, investigating its various properties. Initiate class discussion around the following questions:
"What did you find out about the Magic Purple Liquid?"
"What happened to the water?"
"Where did the 'magic' purple liquid come from?"



EXTENSION: Natural dyes

A number of naturally occurring substances contain dyes which can be extracted and used to dye fabric. Look at blueberries, onion skins, red sumac, black walnut, and goldenrod. You might wish to do an art project with textiles using natural yarn dyed with colors obtained from these and other substances. Also, students may be interested in finding out how the Indians used natural dyes in their clothing.

ACTIVITY BLOCK B--WHAT ARE ACIDS AND BASES?

MAIN IDEA:

Acids will turn certain substances (such as red cabbage water) red, and bases will turn certain substances (such as red cabbage water) green. When acids and bases are added in the proper proportion, a neutral solution results (neither acid nor base).

FOCUS:

Paraphrase: The other day we saw that some things will turn the water from red cabbages red, some things will turn it yellow, and some won't change it at all.

Question: Which things change the color of red cabbage water?

MATERIALS:

Red cabbage water in several quart containers; small containers each labeled and filled with lemon juice, lime juice, orange juice, cider, vinegar, baking soda solution, solid baking soda, ammonia solution, distilled water, tap water, table salt solution, solid table salt.

ACTVITY 1

PROCEDURE:

Divide the students into groups of three or four. Provide each group with the labeled containers, red cabbage water, and some paper toweling.

Each group is to (1) predict what color each of the substances will turn the red cabbage water, writing its predictions on the upper part of the table (see attached sheet to be duplicated for student group use; (2) test each substance and to observe what effect it has on the color of the red cabbage solution, recording the group's observations on the bottom of part of the table.

ACTIVITY 2

Provide each group with 1 tablespoon of baking soda, 1 cup of water and 1 cup of vinegar.

Instruct the students to prepare a baking soda solution by adding 1 tablespoon of baking soda to 1 cup of water. Ask the students "What color does this solution turn red cabbage liquid?" and "What color does vinegar turn red cabbage liquid?" Instruct the students to add a drop of vinegar to the baking soda solution. Ask the students, "What happens?" Instruct the students to slowly add the vinegar to the baking soda solution until the bubbling just stops. Ask the students, "What color does this turn red cabbage liquid?"

FOLLOW-UP DISCUSSION:

Have the groups share their observations, discuss any discrepancies in their results, and do further experiments, if necessary, to come to some agreement. At this point, they should be ready to learn terminology if they haven't already. You could say something like this: "You have divided all of the things into 3 groups. Some of these things turn red cabbage water red, some turn it yellow, and some don't change it at all. We have special names for each of these groups (have the students write these names on their data table). Those things that turn red cabbage solution red are called ACIDS; those things that turn red cabbage yellow are BASES; and those things that don't change the color of red cabbage solution are NEUTRAL."

EXTENSION:

Litmus and bromthymol blue are other substances that test for acids, bases, and neutral substances. The groups may want to take another day using these indicators as well.

ACTIVITY BLOCK C - HOW DO ACIDS CAUSE POLLUTION?

MAIN IDEA:
Acids are environmental pollutants.

FOCUS:
Paraphrase: "We have seen that we can divide substances into acids, bases, or neutral things. Many acids are useful. Lemon juice, orange juice, lime juice, cider, and vinegar are found in foods. Some acids are dangerous. Examples of acids that can be dangerous are battery acid (sulfuric acid), hydrochloric acid and nitric acid. You may have heard about acid rain. Lately it has been in the news a great deal."
Question: What causes acid rain? Why is acid rain a problem? What can be done about acid rain?

PROCEDURE:
Divide the students into groups of four or five.
Each group should plan and implement a project to address these four questions:
1. What causes acid rain?
2. Why is acid rain a problem?
3. What can be done about acid rain?
4. What can we do about acid rain? (Group project)

Each group will need to do research to answer the first three questions. Then group and class discussions with the teacher can generate many group/class project ideas so that each group can then choose, plan, and implement one. These projects could be as follows: a newspaper to distribute to other classes, parents, etc., (see attached sample); letters to state and U.S. legislators, business leaders, etc.; posters and murals to present the problem and urge alternative solutions; a special T.V. show documentary or news show; pamphlets to distribute throughout the school and community explaining the problem and highlighting what can be done; a mock hearing with each group member role playing a different interest/concern in the acid rain problem, etc. Students will undoubtedly come up with other creative ways to present or share their new knowledge about acid rain, its implications for the environment, and further implications for concerned citizens.

NOTE: The entire class could do just one big project using a division-of-labor strategy to delegate the tasks to the various groups.

EXTENSION:

Undoubtedly students will run into the concept of pH throughout their readings about acid rain. It may be useful to show the students the pH scale found on the first page of the Acid Rain Fact Sheet for Teachers. However, this does not make clear to students the logarithmic nature of the scale (that is, why a pH of 6 has 10 times more hydrogen ions--the active part of acids--than a pH of 7, and a pH of 5 has 100 times more ions). One way the students can more graphically observe the pH scale is to have the students represent pH units. Make labels for the students on strings to wear around their necks, with:

1. pH = 7 - pure water
2. pH = 6 -
3. pH = 5 -
4. pH = 4 -
5. Mean pH of Adirondack Lakes in 1930 (pH = 6.5)
6. pH of pure rain (pH = 5.6)
7. Mean pH of Adirondack Lakes in 1975 (pH = 4.9)

You will also need a string about 33 feet long (11 yards). Have the "pH = 7" students start, holding one end of the string, in a corner of the classroom. The student representing pH = 6 should hold the string 10 cm (4") away. The student representing pH = 5 should hold the string 100 cm (40") away, and the student representing pH = 4 should hold the string 1000 cm (400" or 33 feet) away. Point out the location of the following pH values:

mean pH of Adirondack Lakes in 1930 (pH = 6.5)--3.16 cm or 1 1/4" away

pure rain (pH = 5.6)--25 cm or 10" away

mean pH of Adirondack Lakes in 1975 (pH = 4.9)--125 cm or 50" away.

TEACHER PREPARATION:

Do some background reading on acid rain and provide the students with some resources for their group projects. (See attached Acid Rain Fact Sheet for Teachers.)

COLOR CHANGES WITH RED CABBAGE WATER

	TURNS RED	STAYS PURPLE	TURNS GREEN
PREDICTED			
OBSERVED			

ENVIRONMENTAL NEWS

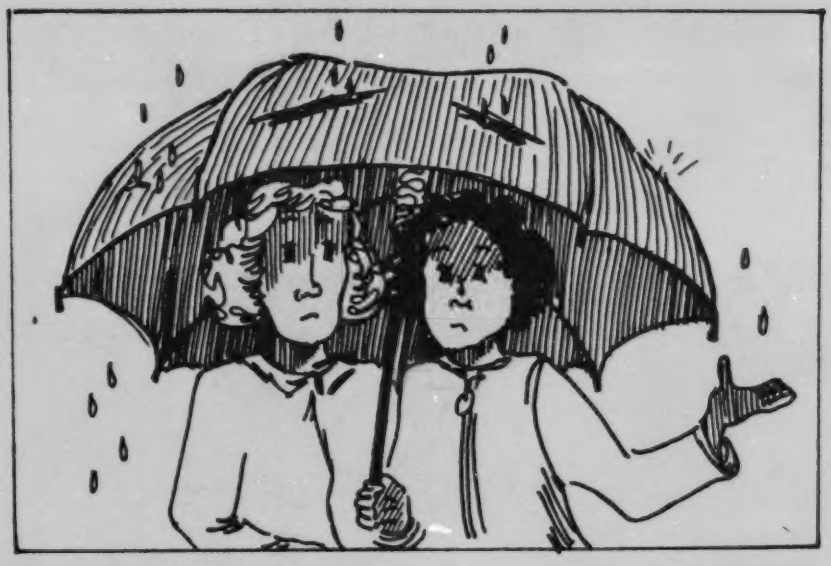
ACID RAIN FALLS ON LAKES

Story By:

DEAD FISH FROM ACID RAIN

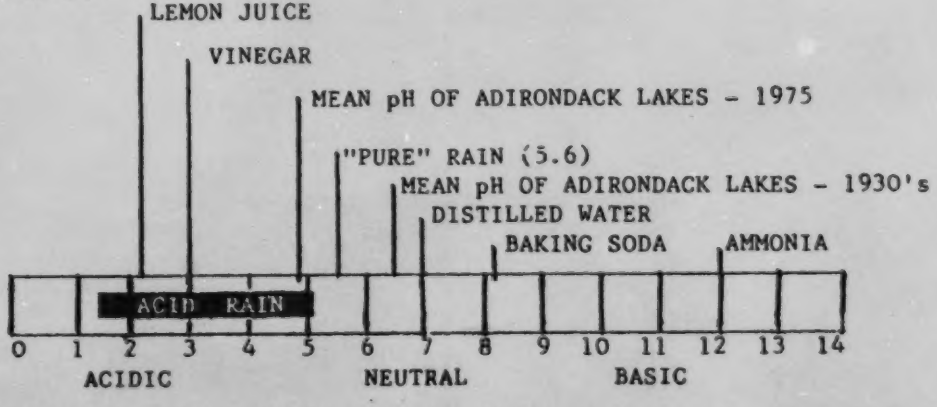
DAMAGE TO CROPS

ACID RAIN PACKET FOR TEACHERS



WHAT CAUSES ACID RAIN?

Precipitation with a pH lower than that of normal rainfall is termed "acidic." A pH value is a measure of the number of hydrogen ions (the active elements of acids) that are present. The more hydrogen ions you have, the greater the pH. A pH is measured on a scale from 0-14, with low numbers indicating acids and high numbers indicating bases (or alkalis) such as lye and ammonia. Pure water has a pH of 7.



Since the pH scale is a logarithmic scale, a change of a pH from 7 to 6 represents 10 times as many hydrogen ions, a change from 7 to 5 represents 100 times as many ions, and a change from 7 to 4 represents 1000 times more hydrogen ions.

Natural rainfall is slightly acidic, with a pH of 5.6. This is due to the fact that carbon dioxide in the atmosphere combines chemically with the rain to form carbonic acid (the same thing that is in carbonated beverages).

Gases such as sulfur dioxide and the nitrogen oxides are also able to combine with rain to form acids. Sulfur dioxide (SO) is naturally produced during volcanic eruptions, but a significant amount is also produced as a byproduct of burning coal containing sulfur (which most of our coal contains) and by metal processing factories. When sulfur dioxide combines with water, it forms a strong acid--sulfuric acid (H_2SO_4). Nitrogen oxides (NO_x) are found in automobile exhaust. These combine with rain to form nitric acid--another strong acid.

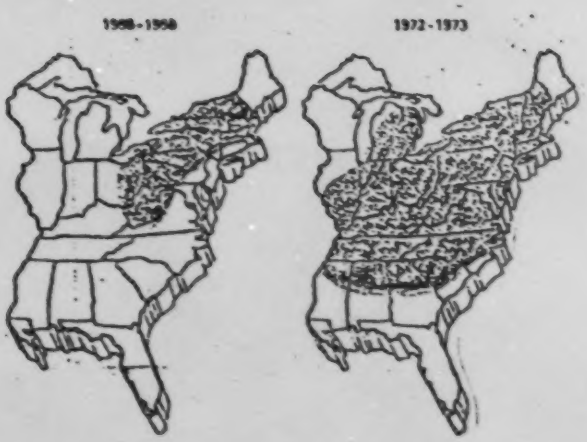
WHY IS ACID RAIN A PROBLEM?

Areas such as the Adirondack Lakes of New York State and the northern parts of Minnesota and Wisconsin are especially sensitive to damage from acid rain because they have lakes with a hard granitic bottom. Lakes which have limestone bottoms are able to neutralize the effects of the acid rain because the limestone acts like a buffer. However, mountain lakes, or lakes in areas where glaciers have scraped off the top layers of rock, cannot neutralize the acidity and so the acid concentration in the water builds up, killing fish and living organisms.

Both plants and animals are affected by a drop in pH. Interference with reproduction in fish occurs with even a small decrease in pH, leading to barren lakes. Ninety lakes in the Adirondacks are fishless because of acid conditions. The productivity of plants is also reduced due to acid rain.

In addition to damage to plants and animals, acidic conditions leach heavy toxic metals (such as mercury, lead, and arsenic) from soil and introduces these into the food chain. Statues and stone monuments (such as the Parthenon in Greece) are also being worn away by the acid precipitation.

The shaded region in the map below demonstrates the extent to which the acid rain problem has spread across the United States. Shaded areas have an average rainfall with a pH of less than 4.5.



WHAT CAN BE DONE ABOUT ACID RAIN?

The acid rain problem is a direct result primarily of the use of coal as a fuel source and secondarily of auto exhaust emissions. Certainly, stiffer regulations to limit the amount of sulfur dioxide and nitrogen oxides would reduce the amount of acid rain, but the only sure measure is to use alternative energy supplies that don't cause environmental damage. This will most likely demand that consumers change their lifestyles and use less energy. An International Joint Commission has been established between Canada and the United States to try to regulate the emissions of pollutants on an international scale.

In addition to changes in energy sources, a great deal of research needs to be done to understand the causes and effects of acid rain. It might be worthwhile to point out to students that scientists don't have all of the answers. Perhaps one of them will help to discover what can be done about acid rain.

EARTH SCIENCE

UNIT

THE WATER CYCLE

MODULE OVERVIEW

The following activities are designed to allow students to explore the phenomena of evaporation and condensation which make up the water cycle. These ideas will be introduced using a model of the water cycle. Questions raised by the model will be explored through a series of hands-on activities which will require the student to make observations and predictions to help them understand concepts associated with the model. It is not necessary for all of the students to do all of the activities. Allow their interests and questions to guide you in the selection of appropriate activities, and don't feel limited to the activities described here. Many students will raise questions that can lead them into designing their own experiments.

APPROXIMATE TIME: 1 week

KEY CONCEPTS FOR THE MODULE

A. When water is heated, it turns into a gas (water vapor) by a proces known as EVAPORATION.

B. When water vapor is cooled, it turns into a liquid by a process known as CONDENSATION.

C. In nature the processes of evaporation and condensation go on continuously and are referred to as the WATER CYCLE.

MATERIALS NEEDED FOR THE UNIT

Gallon glass jar, small container (e.g., baby food jar), plastic wrap, assorted containers, measuring cup, thermometers, pitcher, plastic glasses, ice, water cycle wheels.

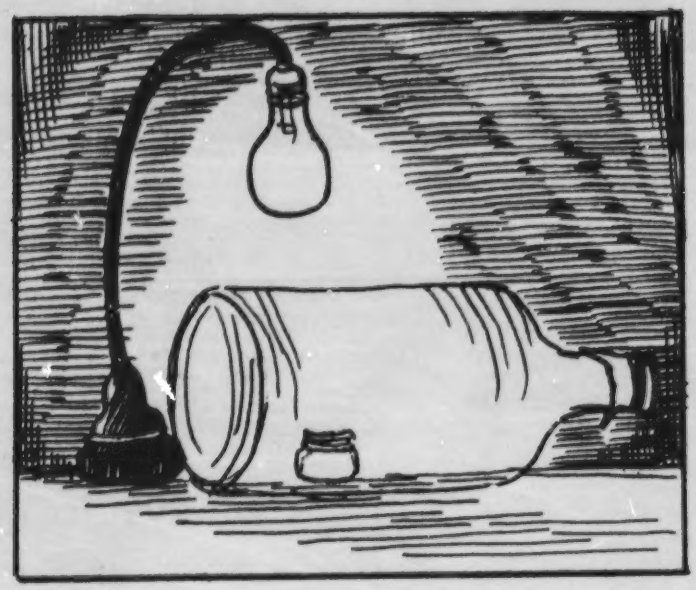
INTRODUCTORY ACTIVITY

PREPARATION SUGGESTIONS:

A simulation model of the water cycle is a useful way to illustrate the concepts of evaporation and condensation while at the same time serving as a good motivator for discussion.

Directions: FOR GOOD RESULTS, SET UP THE MODEL ONE DAY BEFORE OBSERVATIONS ARE TO BE MADE.

1. Obtain a 1 gallon glass jar or some other large container such as a small aquarium.
2. Fill a small container (such as a baby food jar) with water and place it at one end of the large container.
3. Seal the large container with plastic wrap.
4. Place the model so that one side will be warmed (for instance, near a lamp, a heater, or in the sun).
5. The model is ready for use when you see droplets of water at the cool end of the jar.



PROCEDURE:

1. Draw the students' attention to the model with a question such as, "What do you see happening in this jar?"
2. From the comments and questions generated by the students as the various groups share their observations and inferences, initiate a discussion with some questions such as the following:
   a. "What do you see in the jar?"
   b. "Where in the jar are the water drops forming?"
   c. "Is one part of the jar warmer or cooler than the other?"
   d. "Where do the drops of water come from?"

ACTIVITY BLOCK A--WHAT IS EVAPORATION?

MAIN IDEAS:

1. Energy (in the form of heat) is necessary for evaporation to take place.
2. An increase in heat will increase the rate of evaporation.

MATERIALS:

Assorted containers, measuring cup, thermometers (one per group).

SAFETY CONSIDERATIONS:

Remind students to use the thermometers for measuring temperatures only (e.g., not for stirring) and that they are breakable.

PREPARATION SUGGESTIONS:

No advanced preparation is necessary except to obtain the necessary materials. Students will set up the activities in class.

FOCUS:

Paraphrase: "In the model that we observed, we saw that water drops collected on the side of the jar. The next few activities will help us to see where that water comes from."

Question: Where in the classroom does evaporation take place the fastest?

PROCEDURE:

Using the same groups that were formed the day before, provide each with a container and one cup of water. (Be sure that each group uses the same amount of water.)

Each group is to choose a loacation that they predict will effect the fastest rate of evaporation. They should place their container on that spot. All containers are to sit there overnight. The next day, each group should measure the amount of water left in their container and report that amount to the rest of the class.

FOLLOW-UP DISCUSSION:

From the comments and questions generated by the groups' results, initiate a follow-up discussion with questions such as:

a. "Which container showed the greatest amount of evaporation?"

b. "What might have caused the faster rate of evaporation?"

(Evaporation will have taken place faster in most cases if the containers have been placed near heat of if a wind is blowing over them.)

EXTENSION: Further Investigation

At this point you might challenge groups to design tests to find out how each of the following factors affects the rate at which water evaoporates: temperature, movement of the air, amount of liquid exposed to the air, kind of liquid, amount of moisture in the air, etc. Discuss the necessity of setting up at least two conditions for each test, so that results can be compared and the importance of varying one factor at a time (i.e., controlling variables).

ACTIVITY BLOCK B -- WHAT IS CONDENSATION?

MAIN IDEAS:

1. When water vapor is cooled, the vapor condenses into drops of liquid water.
2. In order for rain to form, three conditions are necessary:
   a. the air must be saturated with moisture
   b. the water vapor must cool
   c. there must be particles for the water to collect on.

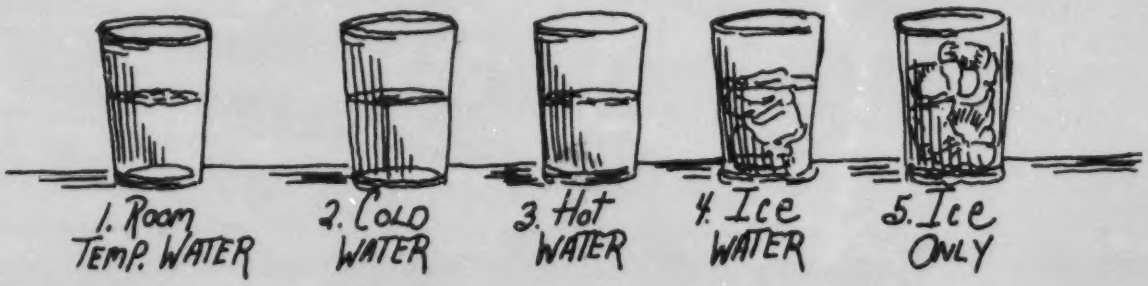
MATERIALS:

Pitcher, 5 glasses, ice.

PREPARATION SUGGESTIONS:

Fill a pitcher with water and ice and set aside for about 15 to 20 minutes until water drops form on the outside of the jar. (If it is extremely dry in the room, it will take longer.) You will need this for the second part of the activity.

Set up five glasses as shown in the diagram below:



FOCUS:

Paraphrase: In the last activities, we saw that if we leave a dish of water out in the air, it will soon be gone (evaporate). In the model that we observed, we saw that somehow the water formed into drops on the side/top of the jar.

Question: Which of these do you think will produce the most water on the sides of the glass?

PROCEDURE:

1. Set up the five glassses as shown above, and then ask the students to predict which of these will produce the most water droplets on the sides of the glasses. Write on the blackboard their predictions and any reasons they give at the start of the activity. Then say, "Let's try it and find out." Have the glasses on a high table or desk so all the students can easily see them, and have them record their observations to see how close their predictions were. Have them predict results if they can and write these on the blackboard as well. (The ice water glass should produce the most drops; but with a humid room, the glass of ice may, too, especially if the ice is touching the sides of the glass.

2. Now, put the pitcher of ice water in front of them and draw their attention to the drops of water on the side of the glass.

FOLLOW-UP DISCUSSION:

Have the students share their observations and use the comments and questions generated by the students to initiate a follow-up discussion to help them to understand the concepts they have been exploring in the activities of this module. Help them use the information they obtained to understand what happened with the ice pitcher, the original model used at the beginning of this module, and, finally, to understand how rain is formed. The following background information might be helpful.

TEACHER BACKGROUND INFORMATION:

The moisture-filled air around the glass pitcher was cooled by the icy pitcher so that the water collected on the side of the cold glass. The moisture in the air that came from the water evaporating from the little jar in the big container (the model from the first day) was cooled sufficiently to condense, collecting on the side of the glass away from the heat source. In order for water to condense (1) the air around must have water vapor in it; (2) the air must be cooled, and (3) something for the water to collect on must be available. So, too, rain is formed when (1) the air in the atmosphere (the clouds) has water vapor in it; (2) the air is cooled, and (3) there is something for the raindrops to form on (i.e., dust particles).

ACTIVITY BLOCK C -- WHAT IS THE WATER CYCLE?

MAIN IDEAS:

Water exists in nature in different forms and these forms are interchangeable through a process called the water cycle.

MATERIALS:

Handouts for making water cycle wheels.

FOCUS:

Paraphrase: In the last few activities we have seen that if a dish of water is left out, the water will soon evaporate (turn into water vapor so we can't see it). When the air is cooled, the moisture in the air will form into drops of water (condense). The next activity will help us to see how these processes (evaporation and condensation) are involved in nature to make rain or snow (precipitation).

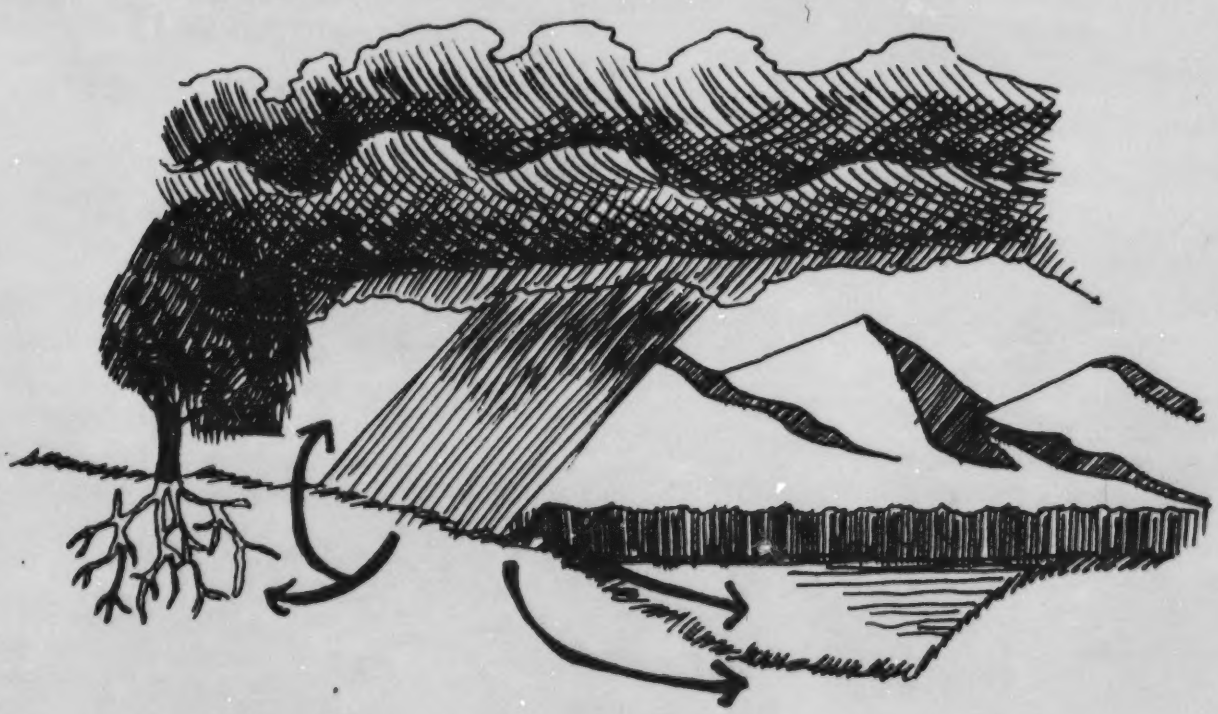
Question: What is the water cycle?

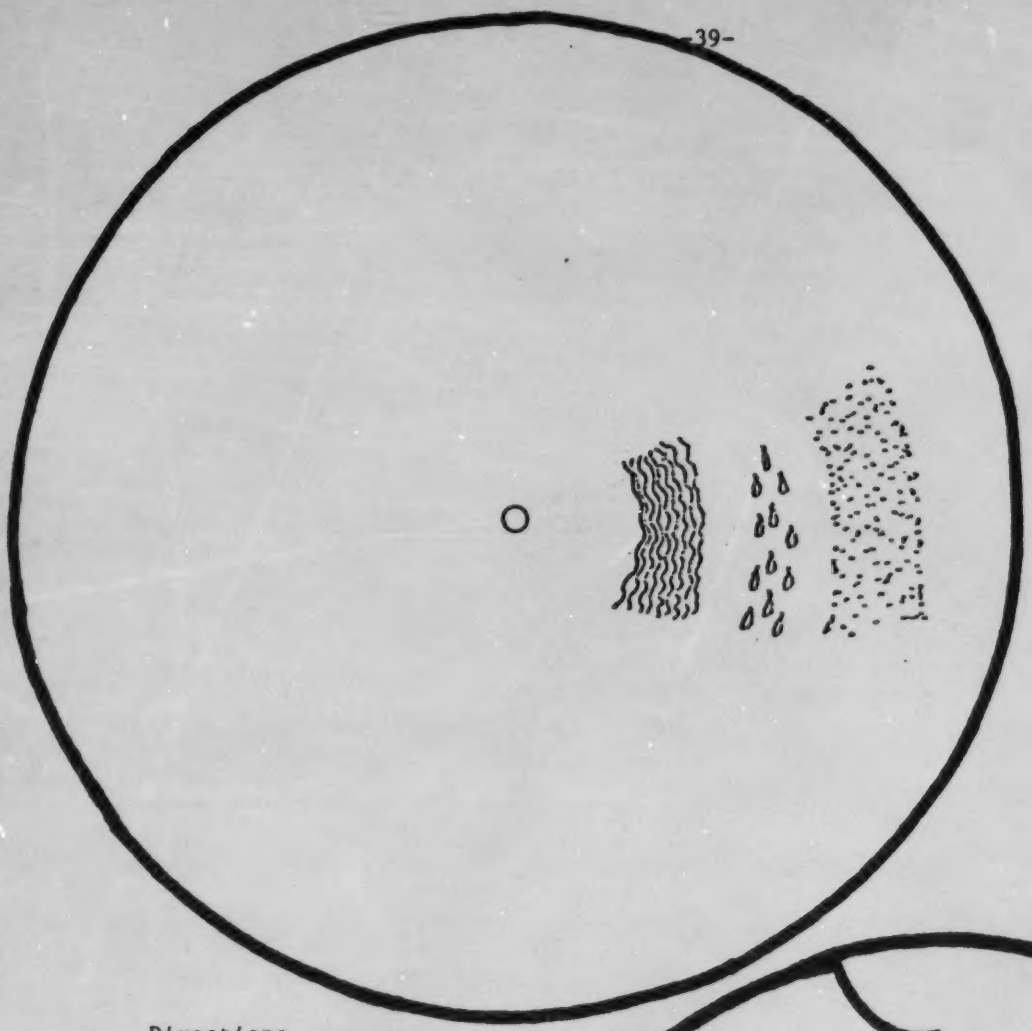
PROCEDURE:

Pass out the materials for making the Water Cycle Wheels. Allow them time to color and construct them.

FOLLOW-UP DISCUSSION:

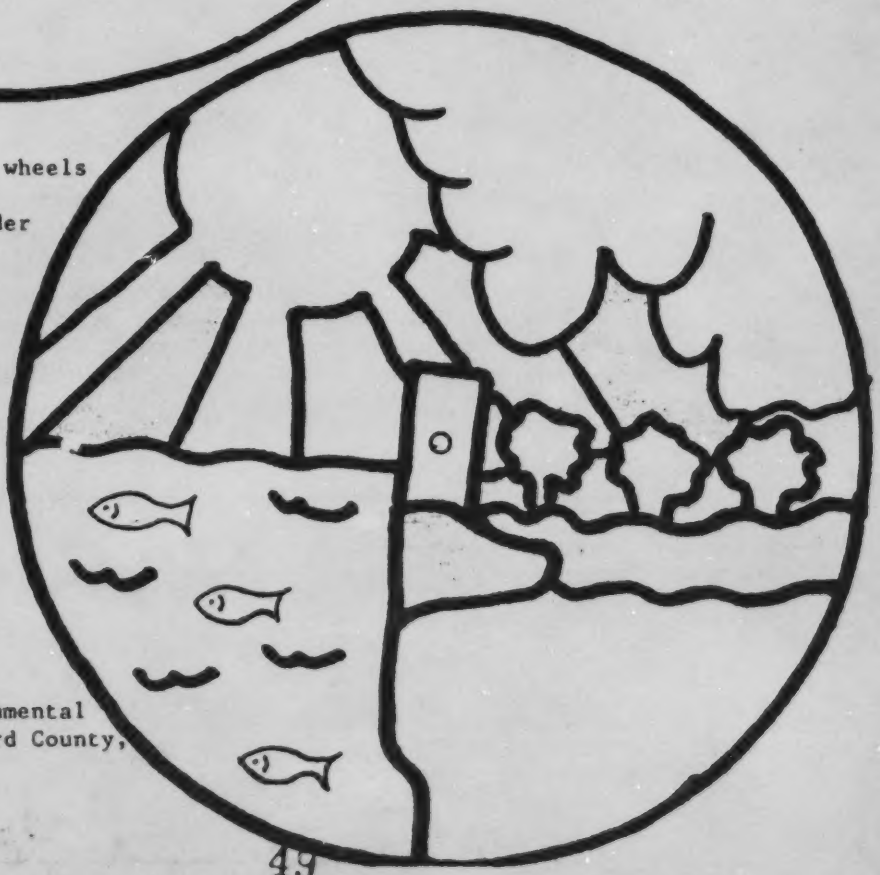
For the follow-up discussion to the Water Wheel activity, use the simulation model again. Have them decide as a class how the model should work if it is attempting to explain what happens in nature (relating what they observed in the model as well as in nature).





Directions

1. Color both wheels.
2. Cut out the complete wheels and the dark areas.
3. Put the top wheel under the bottom.
4. Fasten with a brass fastener.



WATER CYCLE WHEEL
Adapted From:
Interdisciplinary Environmental Education Project, Broward County, Florida

MINNESOTA'S GLACIAL PAST

MODULE OVERVIEW

In this second module, the students will construct time lines to help them understand the concept of geologic time. They will study the state's geologic history, visually depicted by a flip-booklet. Stream tables will be used to study the formation of kettle lakes.

APPROXIMATE TIME: 1 week

KEY CONCEPTS OF THE MODULE

A. Events in history can be expressed on a time line.

B. During Minnesota's past, glaciers have alternately covered and uncovered the state, leaving their mark upon the face of the land.

C. Many of the lakes in the state were formed when large pieces of a glacier broke off and melted, forming kettle lakes.

MATERIALS NEEDED FOR THE MODULE

Rolls of adding machine tape, Glacial Flip-Booklets.

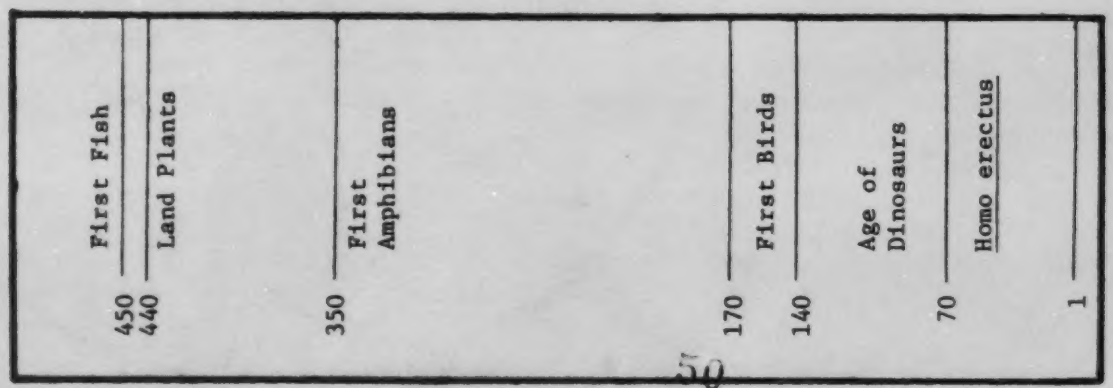
INTRODUCTORY ACTIVITY

TEACHER BACKGROUND:

Discussion of vast amounts of time can be very confusing to the elementary student. For this reason, it is suggested that a graphic means be used. This can best be accomplished with a time line where time is represented as distance on a long piece of paper. The following activity will use a time line represented on a piece of paper 5 meters long. The time period represented is 500 million years; hence each centimeter represents 1 million years.

PREPARATION SUGGESTIONS:

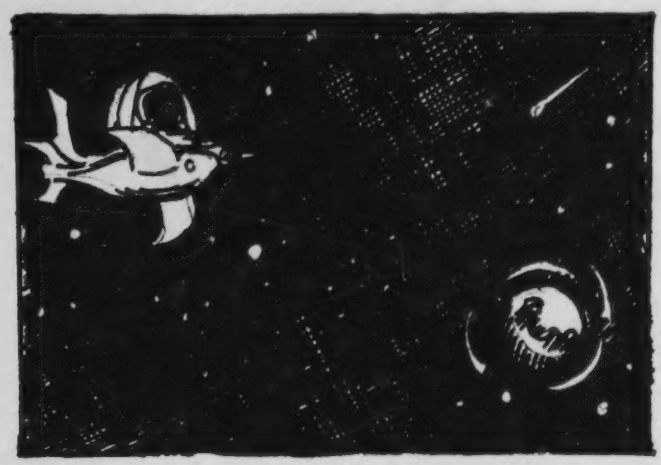
Prepare the time line illustrated below using a 5-meter roll of paper. Remember, each centimeter represents 1 million years, so the mark for 140 million years ago should occur 140 centimeters to the left of the right hand margin of the paper. Also, place the day's date to the right.



PROCEDURE:

Introduce the time line with the following story.

"Imagine that you are an ancient astronaut exploring the universe. One day you are traveling near a star listed on your star chart as the sun when you notice something remarkable. Off to the side there is a swirling mass of dirt and gases. You decide to stay around for a while and watch. As you do, the swirling mass starts to harden into a large ball.



"If you had been that ancient astronaut, you would have been watching the birth of the earth. Scientists believe that this happened nearly 4 and 1/2 billion years ago. Four and one-half billion years is very hard to imagine. One way that we have of thinking about very long times is to use a time line. On a time line, years are changed into distance. We will use a time line that is 5 meters long. Our time line is going to represent 500 million years of time." (NOTE: Each centimeter will represent 1 million years.)

Slowly unroll the time line from the present to the past. Have students come up and hold the time line as it is unrolled. Point out the various time periods. Students should be aware of the relatively short history of human organisms. You might also point out that this time line represents only 500 million years. How long would it have to be to represent the history of the earth? (45 meters)

ACTIVITY BLOCK A--WHAT IS A TIME LINE?

MAIN IDEA:

Events in history can be expressed on a time line.

MATERIALS:

Rolls of adding machine tape.

FOCUS:

Paraphrase: We saw that events in the past can be put on a time line. In this activity you will have a chance to make several time lines.

Question: How do you make a time line?

ACTIVITY 1

PROCEDURE:

Divide the class into pairs. Provide each pair with adding machine tape.

Each pair is to make a time line (these will later be shared with the class and perhaps put up on display).

1. Life Time Line

Students should measure/cut out a strip of adding machine tape 15 cm long. Tell them to start at the left side, marking every centimeter and numbering these in order as shown below.

1	2	3	4	5	6	7	8	9	10	11	12

Students should use different colored markers to indicate

1. how old they are today,
2. when they started school,
3. how old they were in each of the different grades.

2. Historical Time Line

Students should obtain a strip of adding machine paper 1 meter (1000 millimeters) long. Each millimeter represents one year. The far right end represents today's date. Ask students, "How many years ago were you born?" Tell them to make a mark that many millimeters from the right edge.

Students should find out how long ago each of the following events took place by subtracting that date from today's date. That will tell them how many millimeters to measure from the right. Have them make a picture to illustrate each event:

1. Civil War--1864
2. Declaration of Independence--1776
3. Columbus' voyage to America--1492

ACTIVITY 2

As a class project, students may wish to make a large time line going back to the last glaciers in Minnesota. The last glaciers are thought to have left the state about 10,000 years ago. With each millimeter representing one year, they would need 10 meters (about 33 feet) of tape. Perhaps this would be a good "hall project."

Mark on the tape such events as:

1. students' ages
2. age of the school
3. the year your city was founded
4. the year Minnesota became a state (1858)
5. the signing of the Declaration of Independence (1776)
6. Columbus' discovery of America (1492)
7. the disappearance of glaciers in Minnesota (10,000 years ago)

ACTIVITY BLOCK B--WHAT DID THE GLACIERS DO TO MINNESOTA?

MAIN IDEA:

During Minnesota's past, glaciers have alternately covered and uncovered the state, leaving their mark upon the face of the state.

MATERIALS:

"Minnesota's Glacial Past" handout, Glacial Flip-Booklet

FOCUS:

Paraphrase: "In the last activity we saw that events of the past can be put on a time line to help us to picture the great lengths of time involved. In this activity we will look at some of the events in Minnesota's past, especially the glaciers that helped to make the rivers and lakes of the state."

Question: How did the glaciers change the face of Minnesota's land?

PROCEDURE:

Divide the class into groups of three to do the following two activities.

ACTIVITY 1

Each group should answer these three questions after reading the handouts and perhaps doing further research.

1. What is a glacier?
2. When were glaciers in Minnesota?
3. How did glaciers affect the way Minnesota looks today?

NOTE: Students will need to do research to answer these questions. Since materials on glaciers for students might not be readily available, the handout "Minnesota's Glacial Past" should provide the background information that the students would need to answer the last two questions. Also, the flip-booklet on Minnesota's glaciers will help the students to visualize these changes.

ACTIVITY 2

Each group should carefully plan and implement (after the teacher has checked over the plan) a project such as the following: a newspaper describing the glacier's activity, posters and murals, a TV show (news, "talk," or documentary format), pamphlets to distribute, etc.

NOTE: These projects could be presented to the rest of the class (or to other classrooms in the school) and shared with parents.

FOLLOW-UP DISCUSSION:

Have each group share their responses to the questions (have them turn in their group papers for evaluation purposes) and develop the discussion until you feel they have sufficient background to plan the group projects.

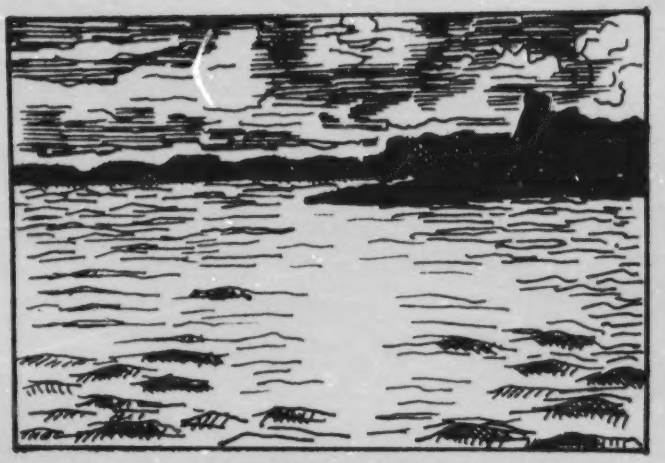
MINNESOTA'S GLACIAL PAST

THE FACE OF THE LAND

Roughly four and one-half billion years ago a very remarkable event took place. Out of a swirling mass of gases and dust a new planet was formed—or so scientists have guessed. The first four billion years of the earth's history were so full of changes that there are very few records of any kind to show scientists what this time was like. Violent volcanoes and earthquakes, molten lava and poisonous gases covered the earth. It is not surprising that life didn't appear on the earth until the earth had cooled, oceans had appeared, and the atmosphere had changed to the oxygen and nitrogen atmosphere that we now know. This first appearance of life occurred about 500 million years ago. These early life forms were very small water plants and animals.

How do we know about the earth millions of years ago? Certainly there were no people to write histories. The few records that we do have of the early history of the earth come from studying rocks. When you look at pictures of the Grand Canyon, you immediately notice the bright bands of color in the rocks. These bands represent different kinds of rocks that were formed during different periods of the earth's history. By studying these bands of rock, scientists can learn a great deal about the way that the earth was formed during the first four billion years of the earth's history.

What were some of the events that occurred in Minnesota during these early years? At first the earth was covered with seas of hot lava that poured from the center of the earth. Pressures building up inside of the earth caused great mountains to be lifted up. These mountains towered over Minnesota for millions of years until wind and rain eroded them away leaving only the granite hills along Lake Superior's north shore as a reminder of these prehistoric mountains.



Oceans covered part of Minnesota on several occasions. Five hundred million years ago seas covered all but the northernmost tip of Minnesota. Fossil remains of ocean animals are a reminder of this time when Minnesota was under water. Twice more, 400 million years ago and 350 million years ago, Minnesota again formed the ocean bottom for a vast world-wide sea.

The climate of Minnesota also went through many changes during the time from arctic cold to tropical warmth. During the cold periods, the state was often covered with great sheets of ice. During these Ice Ages tremendous changes took place in the face of Minnesota, resulting in the lakes and rivers, hills and valleys that make up the Minnesota that we know today.

Up to this point we have been speaking about Minnesota, but really the State of Minnesota as a geographical location is a very new idea considering the vast amounts of time that we are talking about. Minnesota became a territory in 1848 and a state in 1858--just a little over a hundred years ago. Just think of all of the changes that this land went through before humans divided it up into political units of counties and states.

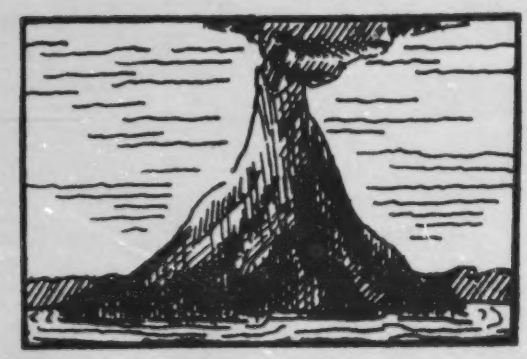
The State of Minnesota lies roughly between 90 and 97 degrees west longitude (lines that extend between the north and south poles) and between 43 and 49 degrees north latitude (lines parallel to the equator). This puts it roughly in the middle of North America (see the map of North America). The area of Minnesota is 84,068 square miles and the 1975 estimated census was 3,926,000. This makes the state 12th largest in size and 19th largest in population.

Minnesota is referred to as the "Land of 10,000 Lakes," but in reality there are more than 14,000. During the latest glacial age, the state was covered by six great lakes, the largest of which, Lake Agassiz, covered the northern quarter of the state. These lakes, along with the Glacial River Warren, formed drainage areas which would later become rivers and lakes.

We have looked at some of the changes that have occurred to form the Minnesota that we recognize today. Volcanoes, earthquakes, and glaciers have worked together to form the lakes, rivers, hills, and valleys of the state.

FORCES THAT HAVE FORMED THE LAND

The formation of the earth involved many violent forces. The heat and pressure necessary to form the swirling mass of gases and dirt into a solid sphere also created internal pressures that continually cause the earth to change. The cooling of this hot sphere caused shrinking, wrinkling, and folding, resulting in the uplifting of mountain ranges.



There are still some reminders of this long ago time in the hot, molten core of the earth. Occasionally this molten core will find a weakness in the earth above through which to emerge. This is referred to as a volcano.

Most people are familiar with such volcanoes as Vesuvius in Italy and Mauna Loa in Hawaii. Many of the world's mountains are former volcanoes. Remnants of volcanic rock found in Minnesota show that the state once contained active volcanoes.

Volcanic mountains are not the only form in which molten material may be brought to the surface. Often molten lava will force its way between older rocks and flow to the surface. The north shore of Lake Superior is an example of a region in which lava formed large sheets of igneous rock as it forced its way to the surface. One of the oldest known kinds of rock on the surface of the earth, the Ely Greenstone, is an example of this type of rock formation.

Volcanoes are often associated with violent movements of the earth called earthquakes. Earthquakes generally occur along lines of weakness in the underlying rock referred to as faults. Pressure, either due to shifting rocks or to underground molten rock, cause movement of huge rock masses along the fault line. Earthquakes result from very rapid movements.

However, movements of large masses of land occur commonly at a very slow rate. Many of the continents and mountain ranges have been formed by gradual movements of land masses. These processes take millions of years.

While volcanoes and earthquakes tend to build up land structures, the third force, erosion, tends to level off the land. Whenever rocks are exposed they tend to be worn away by the action of wind and water, which breaks rocks into tiny fragments and carries them away. Gradually, over millions of years, great mountain ranges may be leveled or huge canyons carved by the action of moving water.

Other types of weathering may occur. The freezing and thawing of water in rock cracks may result in large pieces of stone breaking off. Biological species such as lichen have the ability to dissolve rock and use the minerals for food. The action of waves will continually change the appearance of a beach.

All of these processes have had a part in the formation of Minnesota as we now see it. However, the most important process has not even been mentioned yet. That is glaciation.

MINNESOTA'S GLACIAL PAST

Without a doubt the most important factor in determining the face of the land for the State of Minnesota was the tremendous force exerted by glaciers. Four major ice ages covered Minnesota, the last being as recent as 11,000 years ago.

The first major ice age, the Nebraskan Ice Stage, occurred 2 million years ago. This ice sheet extended as far south as St. Louis, Missouri. This ice probably covered all of Minnesota, with the exception of a small region in the southeast corner of the state. However, it is hard to tell anything more about the effects of this ice sheet, because most of the effects were wiped out by the next ice age.

We do know that this ice age lasted for a very long time. It was followed by a warmer, moist period. During this interglacial interval, the huge wooly elephant, the mammoth, roamed the state.

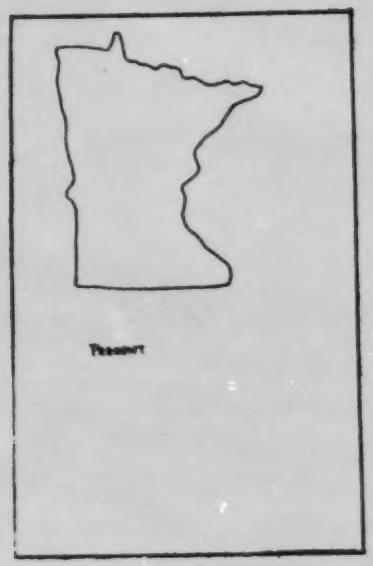
The second ice age occurred 400,000 years ago. This ice age, the Kansas Ice Stage, extended as far south as Kansas City. Again, this ice stage covered almost all of the state, with the exception of a small region in the southeast corner.

A very long warm period followed this glacial age. The giant beaver and the giant sloth were thought to be common at this time. The giant beaver was roughly the size of a black bear, ranging up to nine feet long and weighing up to 500 pounds. Fossil remains of this animal can be seen at the Science Museum of Minnesota, in St. Paul.

One hundred and fifty thousand years ago a third ice age, the Illinoisian Ice Stage, covered most of Canada with major ice movements (called lobes) extending into Minnesota and Illinois. Again, Southeastern Minnesota was not covered by the ice. This ice age may have only lasted a few tens of thousands of years.

The period between the third and fourth ice ages was cooler than the previous interglacial periods. The mastadon, another form of the elephant, was found in the state during this time.

The final ice age began 100,000 years ago and lasted for about 90,000 years. This period, referred to as the Wisconsin Ice Stage, had many lobes which significantly formed the present topography of Minnesota. This period is very complicated. Three major lobes, the Wadena Lobe (later extended as the Grantsburg Lobe), the Superior Lobe, and the Rainy Lobe alternately extended into and retreated from the state (see Figure 3).


Present

11,000 years ago

12000 years ago

13,000 years ago

14,000 years ago

15,000 years ago

16,000 years ago

17,000 years ago

18,000 years ago

19,000 years ago

20,000 years ago

21,000 years ago

22,000 years ago

23,000 years ago

24,000 years ago

25,000 years ago

26,000 years ago

27,000 years ago

A GLACIAL FLIP-BOOK

1. Cut out each page of the book.
2. Arrange the pages in order starting with the present and going backward by years to 35,000 years ago.
3. Line up the pages.
4. Staple the left side with two staples.
5. Flip through the book with your thumb and watch the movement of the glaciers.

ACTIVITY BLOCK C--HOW DID THE GLACIERS FORM LAKES?

MAIN IDEA:

Many of the lakes in the state were formed when large pieces of a glacier broke off and melted, forming kettle lakes.

MATERIALS:

Stream Table (see Appendix), ice.

FOCUS:

Paraphrase: "We have seen that the glaciers had a tremendous affect on the way that Minnesota looks today. This activity with the stream table will look at the way that glacial lakes formed."

Questions: How did the glaciers form lakes?

PROCEDURE:

Divide the class into groups, each with their stream table and some ice cubes. Form the sand as shown in the diagram. Mix one end of the stream table with crushed ice. In the other end, partially bury chunks of ice in the sand. Allow the ice to melt and observe what happens. For the best formation of kettle lakes, the sand needs to be fairly wet.

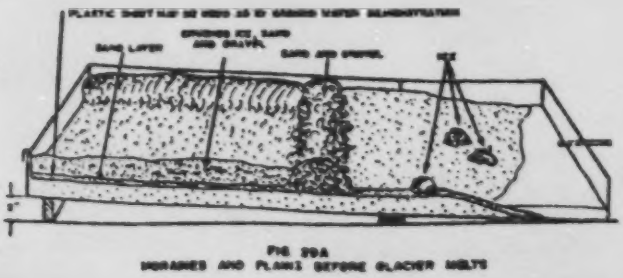


FIG 29A

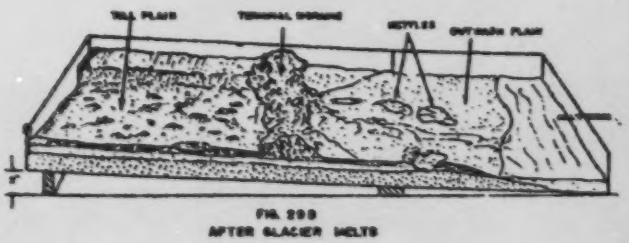


FIG 29B

FOLLOW-UP DISCUSSION:

Ask the students to describe what they have observed. (Little lakes are formed.) These kinds of "lakes" that are formed have a special name because of their shape. Ask the students if anyone knows what they are called? (Accept various answers and then tell them that the "lakes" remaining are called "kettle lakes" because of their resemblance to large cooking kettles.)

ACIDS AND ROCKS

MODULE OVERVIEW

In this module, students will focus on some of the materials that make up Minnesota lake bottoms by studying and classifying various kinds of rocks. They will experiment with the effects of acid (i.e., vinegar) on these rocks to help them understand why some lakes are particularly sensitive to acid rain.

APPROXIMATE TIME: 1-2 weeks

KEY CONCEPTS OF THE MODULE:

A. Rocks can be classified on the basis of their properties.

B. Some rocks will react with an acid (such as vinegar) to neutralize it.

C. Acids can dissolve metals in the water, resulting in toxic (poisonous) materials being released into the water.

MATERIALS NEEDED FOR THE MODULE:

Pop bottle, balloon, baking soda, vinegar, rocks (granite, slate, sandstone, limestone, dolomite), chalk, shallow dishes, galvanized nails, eyedroppers, glass microscope slide or mirror.

INTRODUCTORY ACTIVITY

PROCEDURE:

Place approximately 1" of vinegar in the bottom of a clear soda pop bottle. Put two teaspooons of baking soda into a balloon. The balloon should have been blown up beforehand to "stretch it out." Place the end of the balloon over the neck of the bottle being careful not to let the baking soda and the vinegar mix (see diagram).

Tell the class that the bottle contains an acid (vinegar) and the balloon contains a crushed rock (in reality, carbonates, a class of chemical compounds including baking soda, are found in some rocks). Ask them to watch what happens when the two are mixed.

"What do you see happening when the acid and the crushed "rock" are mixed together?" Students should observe that the balloon blows up and that bubbles were given off from the liquid.

Paraphrase the following:

"We say that the acid and the rock reacted together. How do we know that they reacted?" (That bubbles were formed gives us a clue: something new was formed--a gas.)

"In the next few activities, we will be studying the ways in which the kinds of rocks found in lake bottoms affect how lakes are damaged by acid rain."

ACTIVITY BLOCK A--WHAT ARE THE ROCKS?

MAIN IDEA:

Rocks can be classified on the basis of their properties.

MATERIALS:

Rocks that students have collected or prepared rock collections (see additional resources section).

PREPARATION SUGGESTIONS:

Several days before the scheduled activity, instruct the students to begin collecting rocks. Tell them to look for rocks that look different and are fairly small (about golf ball size).

FOCUS:

Paraphrase: I have asked you to collect and bring in some rocks so that we can study and classify them.

Question: How are these rocks alike and different?

PROCEDURE:

Divide the class into groups of three or four.

Instruct the students to choose five rocks that seem most different in appearance. They should place each rock in a space under the heading "rock." Tell them to think of one characteristic/property of each rock that makes it different from all of the other five rocks, and write that characteristic next to each rock under the column marked "difference." Have them complete the remainder of the chart by describing the color of each rock and whether it is shiny or dull.

Have the students number the rocks with a small piece of stick-on tape, labeling the rock in the first space "1," in the second space "2," and so on until the last.

After they have numbered their rocks, have them trade charts and rocks with another group. Without looking at the numbers, have them see if they can decide which rock goes into which space.

FOLLOW-UP DISCUSSION:

Have each group share their chart with the class. Point out to the students that this is similar to the process that scientists use for identifying rocks.

ROCK	DIFFERENCES	COLOR	SHINY/DULL	DO YOU GET BUBBLES WITH VINEGAR?
1				
2				
3				
4				
5				

ADDITIONAL RESOURCES:

To be sure that the students have a variety of rocks to look at, you may wish to order some of the prepackaged mineral collections available. The following are some sources:

Earth Science Materials
P.O. Box 2121
1900 E. Lincoln Ave.
Fort Collins, CO 80522
(303) 484-2529
(Several kits available)

Turtox/Canboaco
8200 South Hoyne Ave.
Chicago, IL 60620
(312) 488-4100
(Basic collection of 15 rocks and minerals #700-362)

Nasco
901 Janesville Ave.
Ft. Atkinson, WI 53538
(414) 563-2446
(Nasco Rock Collection--SA6362M-DJ6362)

Ward's Natural Science, Inc.
P. O. Box 1712
Rochester, N. Y. 14603
(716) 467-8400
(Cleveland Elementary Science Collection #45W0240)

ACTIVITY BLOCK B--WHICH ROCKS WILL REACT WITH VINEGAR?

MAIN IDEA:

Some rocks will react with an acid (such as vinegar) to neutralize it.

MATERIALS:

Students' rocks (also samples of calcite, granite, slate, sandstone, dolomite, quartz, limestone, and marble, if available) white writing chalk, small shallow dishes, vinegar.

TEACHER BACKGROUND:

The "vinegar test" is a standard identification for the presence of carbonate containing rocks. Sodium carbonate (commonly called "washing soda") and sodium bicarbonate (baking soda) are two carbonates found around the house. Vinegar reacts with these carbonates to produce a rapid burst of carbon dioxide bubbles.

ACTIVITY 1

MAIN IDEA:
Some rocks will react with acid.

MATERIALS:
Students' rocks (also samples of calcite, quartz, limestone, and marble, if available), white writing chalk, small shallow dishes, vinegar.

PROCEDURE:
Provide each student group with the materials listed above. Students should fill a shallow dish with 1/4-1/2 inch of vinegar. They then should place each of their rocks in the dish and observe for the presence of bubbles. If bubbles form, they should put a plus under the heading "Do you get bubbles with vinegar?" If no bubbles form, then they should put a minus.

Have them leave the dishes standing for 24 hours. At the end of that time, have them record any observations in the column, "Do you get any bubbles with vinegar?" Ask the students, "Was there any change in the size, shape, or color of the rocks?"

In another dish also containing 1/4-1/2 inch of vinegar, have the students place a 1 inch piece of chalk and pieces of calcite, quartz, limestone, and marble (if available). Ask them, "What happens? Which reacts most rapidly?"

FOLLOW-UP DISCUSSION:
After the groups have shared their observation sheets, you might want to discuss the relationship between chalk, limestone, and marble (see Teacher Background).

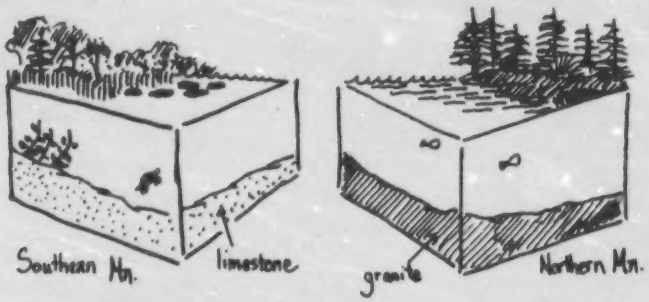
ACTIVITY 2

MAIN IDEA:
The reaction of an acid with a carbonate containing rock will neutralize the acid.

MATERIALS:
Provide each group with three containers, chalk, vinegar, and red cabbage water. (NOTE: Some school room chalks are not carbonates and won't work--try yours first.)

Some rocks contain calcium carbonate, which also reacts with vinegar. Examples of carbonate containing rocks are calcite, limestone, marble, and some forms of chalk. Chalk and limestone will generally react very vigorously with acid. In fact, marble, limestone, and chalk ae really the same things. !rm45 Chalk represents the skeletal remains of dead sea organisms. Time and the pressure of other materials filling in presses these skeletons into chalk. Over thousands of years, more pressure changes this chalk into limestone. Limestone is important to Minnesota, since much of the state lies on a layer of limestone bedrock--one of the indications that Minnesota was once covered by seas. Additional time and pressure may further compress limestone into marble.

Environmentally, this is very important. Some lakes, such as those in south and central Minnesota, have lake bottoms composed of limestone. When acid is added to the lakes in the form of acid rain, the limestone is able to react with the acid to neutralize it. This ability to neutralize acid is referred to as the buffering capacity of the lake. In other areas, such as northwestern Minnesota, the glaciers scraped away this limestone layer, leaving only the hard granite bedrock exposed. Granite will not react with acid to neutralize it; therefore, lakes with this sort of bedrock are very sensitive to damage from acid rain.



FOCUS:

Paraphrase: "In the last activity we saw that we could classify our rocks by things about them that are alike and things that are different. In this experiment, we will look at the ways that some rocks will react with vinegar. What happened to the baking soda in the bottle the other day?"

Question: Which rocks do you predit will react with vinegar?

PROCEDURE:

Tell students to place 1" of vinegar in two containers. In the third container, tell them to place 1" of tap water. Tell them to label the first container "vinegar" and the third "water." Have them add about 10 drops (until there is a definite color) of red cabbage water to each.

Ask the students, "Does the color of the center container look more like the vinegar or the water?"

Have them add a 1/2" piece of chalk to the center container.

Ask the following: "What happens?"

"After the reaction has stopped, does the center container look more like the vinegar or the water?"

"What has the chalk done?"

FOLLOW-UP DISCUSSION:

Have members from each group share their observation sheets. (NOTE: It might be a good idea to remind the students that the reason the vinegar container is red is because it contains an acid (vinegar). The chalk "takes away" (neutralizes) the acidity. Don't leave the students with the idea that vinegar turns into water).

ACTIVITY BLOCK C--WHAT DO ACIDS DO TO METALS IN THE ENVIRONMENT?

MAIN IDEA:

Acids can dissolve metals resulting in toxic (poisonous) materials being released into the water.

MATERIALS:

Each group will need:

Galvanized nails used for nailing shingles (NOTE: galvanized nails are just iron nails covered with zinc to prevent rusting, and they are available in hardware and building supply stores), two containers, vinegar, eyedroppers, and glass slide or mirror.

TEACHER BACKGROUND:

Besides the direct damage that acid rain does to organisms, the acidity also has the property of dissolving metals which had been previously in the sediment at the bottom of the lake. Toxic materials such as aluminum, zinc, and mercury get into the water and from there into the water organisms. (NOTE: The toxicity of many metals depends upon how much of the metal is present. Zinc, for example, is an important nutrient in small quantities, but when too much is present, it becomes poisonous.)

FOCUS:

Paraphrase: "In the last activity, we saw that certain rocks were able to react with acids and neutralize (or 'take away') the acid. This explains why certain lakes are not as sensitive to acid rain as other lakes."

Question: How does acid rain cause poisonous metals to be released into the water?

PROCEDURE:

Tell the students to fill two containers with 1 inch of vinegar. Into one container have them place a galvanized nail (used for fastening shingles). They should leave both containers for 24 hours.

After 24 hours, they should put a couple of drops from each container on a glass slide or mirror. Ask "Do you notice any difference?"

Have them let the drops dry. Ask, "Where do you think that material in the drop from the container with the nail in it comes from?" (NOTE: You may also like to have them try using a lead sinker or steel wool instead of a galvanized nail.)

(This activity is adapted from Easy Experiments with Water Pollution by Harry Sootin, Four Winds Press, N. Y. Used by permission.)

EXTENSION:

Have students research the damage done by acid rain to buildings and monuments. There have been several articles about the damage that is being done to the ancient temples in Rome and Greece, as well as to buildings in New York or London, among others.

APPENDIX

STREAM TABLES

MODULE OVERVIEW

In this first module, students will construct stream tables to help them understand geologic processes that take place on a long time scale. They will carry out experiments with their stream tables to study erosion by water and to study how ground water forms the water table.

KEY CONCEPTS OF THE MODULE

A. Stream tables can be used to study geological changes made by water movement.
B. Streams change in depth and position with time.
C. Ground water (forming the water table) is that portion of precipitation that doesn't constitute surface run-off nor remain in the layer of soil but sinks deep into the ground.

MATERIALS NEEDED FOR THE MODULE:

Cardboard box, plastic bag, masking tape, glue, rubber tube, buckets, sand, one 1 foot long 2" x 4" piece of wood, ice, clothespin

TEACHER BACKGROUND:

Minnesota has a rich and varied geological history. Some of the best examples of the work of glaciers in shaping the face of the land are found in Minnesota. The "oldest rocks in the world," the Morton gneisses (almost 4 billion years old) can be seen in the southwest part of the state. Glacial lakes and ancient river beds are easily accessible to students in the various regions of the state. All of these factors combine to make Minnesota's geological past a study worthy of student investigation.

However, study of changes taking place over billions of years is made more difficult for students because of the tremendous lengths of time involved. Several techniques can be used to help students deal with concepts of changes over long periods of time. A time line (a strip of paper with length units representing time units) give a graphic representation of the relative lengths of time between events in history. A stream table accelerates processes of erosion so that students can observe the effects of water and ice on land.

ACTIVITY BLOCK A--WHAT IS A STREAM TABLE?

MAIN IDEA:

Stream tables can be used to study geological processes over time.

MATERIALS:

For each group's stream table you will need: one cardboard box (approximately 1 ft. wide by 2 ft. long), large plastic garbage bag, masking tape, glue, two 2 foot long rubber hoses or tubing (such as from a surgical supply or hardware store), two cans or buckets, sand, and one 1 foot long 2" x 4" piece of wood.

PREPARATION SUGGESTIONS:

Stream tables have been used extensively in geology and earth science classes for years, but it is only relatively recently that stream tables have found their way into the elementary classroom (see the ESS Unit on "Stream Tables"). Unfortunately, teachers have been hesitant to work with stream tables because of their large size and potential for messiness. However, a number of Minnesota geological principles of interest can be illustrated by a smaller and simpler apparatus described below. You might want to make up a stream table ahead of time as a model for the student groups.

FOCUS:

Paraphrase: "There are lots of ways that the shape of the earth changes. Earthquakes and volcanoes change the face of the earth rapidly. However, there are slower ways that the earth changes. Today we will make stream tables to look at the ways that water changes the shape of the earth."

Question: How does the water change the sand?

ACTIVITY

STUDENT GROUP HANDOUT

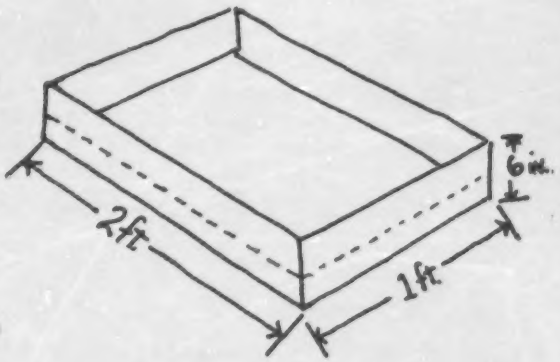
MATERIALS:

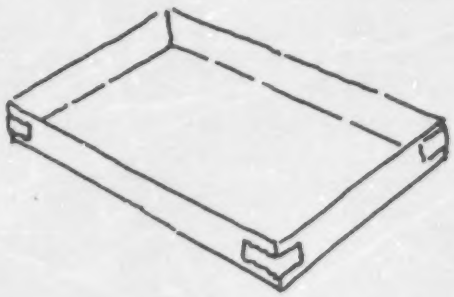
To build your stream table, your group will need the following: one cardboard box (approximately 1 ft. wide by 2 ft. long), one large plastic garbage bag, masking tape, glue, two rubber hoses or tubing, two cans or buckets, coarse sand, one 1 foot long 2" x 4" piece of wood.

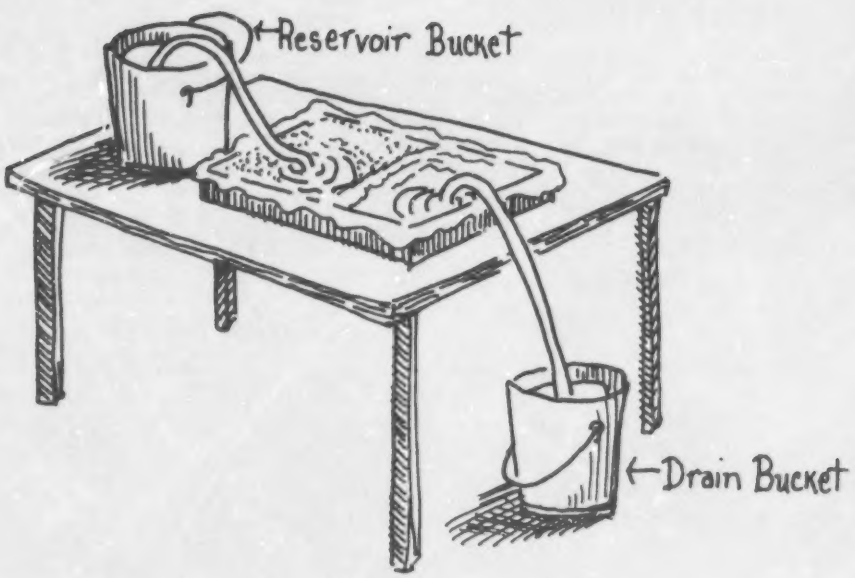
PROCEDURE

To build your group's stream table:

1. Cut the top off the box leaving 6" sides.
2. Ask your teacher to make a cut 3" from the bottom around all sides, but just cut through the outer surface. Do not cut all the way through (see dotted line). Also cut from that point upward at each of the four corners.
3. Fold each of the sides inward along the scored line to give a double outer wall.
4. Securely tape all sides and the bottom to reinforce the box.
5. Apply a layer of glue (or rubber cement) to the inside bottom of the box.
6. Line the box with a large plastic garbage bag. Be sure to leave some of the bag overlapping on all three sides. Smooth the bottom to adhere to the glue.
7. Securely tape the bag to the box on all sides.
8. Arrange the sand in a gentle slope. Fill the shallow end with about 1" of water and allow the sand to soak up the water. Replace more water as needed.
9. Set up the buckets and hoses as shown in the diagram. Start a steady flow of water out of the resevoir bucket and start a steady flow of water into the drain bucket by creating a "siphon" effect: Put the hose into the resevoir bucket, making sure that the bottom of the hose touches the bottom of the bucket. Suck on the free end of the hose until the water begins to flow. Holding your finger over the free end of the hose, lower the hose until it is below the bottom of the bucket and flowing into one end of the stream table. A steady flow of water should result. This flow of water can be controlled by use of a clothespin clamped around the middle of the tube.
10. Now form "mountains and valleys" in the sand, and then turn the water on slowly. Observe how the water changes the sand.






Reservoir Bucket
Drain Bucket

LIFE SCIENCE

UNIT

A MODEL ECOSYSTEM

MODULE OVERVIEW:

In this module, students will set up an aquarium and will make observations and inferences about the interactions among the non-living factors or physical environment and the living organisms or populations in this model ecosystem. Students will then determine the affects of one non-living factor (temperature) on a living organism (fish). This activity will serve as a model for the students' design of their own experiments to test other factors which might affect the balance of their aquarium ecosystem.

APPROXIMATE TIME: 6 to 7 class periods

KEY CONCEPTS OF THE MODULE:

A. The physical environment of an ecosystem is made up of non-living factors which interact with each other.

B. In an ecosystem, living organisms are in constant interaction with each other and their physical environment.

C. An ecosystem depends upon the balanced interaction among the non-living factors or physical environment (e.g., light, temperature, water, soil) and living factors (e.g., plants and animals.

INTRODUCTORY ACTIVITY

You may want to start off this module with an aquarium that you have already made. This would provide a model for the student aquariums as well as a good motivator for many open-ended questions which might lead to student investigations during Activity Block C. Questions such as the following might be used:

1. What do you observe in this aquarium?
2. What things do you observe in the aquarium that appear to be living?
3. What things do you observe in the aquarium that appear to be non-living?
4. Do you see any evidence of a relationship between the living things and the non-living parts of the aquarium?

FOCUS:

Paraphrase: The world in which each plant or animal lives is called its environment (or habitat). The environment contains other plants or animals and non-living things such as soil, temperature, moisture, light, and wind.

We can find many different environments in the area around our homes and school. We can also make different environments in our classroom such as this aquarium. We can then use these water environments (or aquariums) to do experiments that will answer questions about how these living and non-living things interact with one another and what factors might affect that interaction.

Question: What can you find our about the living and non-living things in the aquarium that you will make.

ACTIVITY BLOCK A--WHAT ARE THE NON-LIVING PARTS OF AN AQUARIUM?

MAIN IDEA:

The physical environment of an ecosystem is made up of non-living factors which interact with each other.

MATERIALS:

Large, clear one gallon jar with a wide mouth and a lid, half a pail of coarse sand, crushed gravel, small pebbles, or one bag (500 g) of aquarium gravel from a pet store, a dishpan, a sieve or strainer, a sheet of white paper, and scissors.

PREPARATION SUGGESTIONS:

Allow at least one week of advance notice for students to bring in one gallon jars. Decide whether to have one aquarium per student group or one for each student (which can later be taken home). Hand out copies of the student directions and help set up the non-living portions of each aquarium.

PROCEDURE:

Have student prepare aquariums using the student directions given below. Divide the class into group of three or four to collaborate on the observations and follow-up discussion. Masters for student worksheets are provided on the following two pages.

STUDENT DIRECTIONS

1. Collect the following materials for the non-living parts of your aquarium: large, clear one gallon jar with a wide mouth and a lid, half a pail of coarse sand, crushed gravel, a dishpan, a sieve or strainer, a sheet of white paper, and scissors.

2. Wash the jar thoroughly, but do not use soap or detergent.

3. Put the sand or gravel in the strainer and wash it three or four times until it has been rinsed clean. Remove any twigs, brnaches or leaves that you might find.

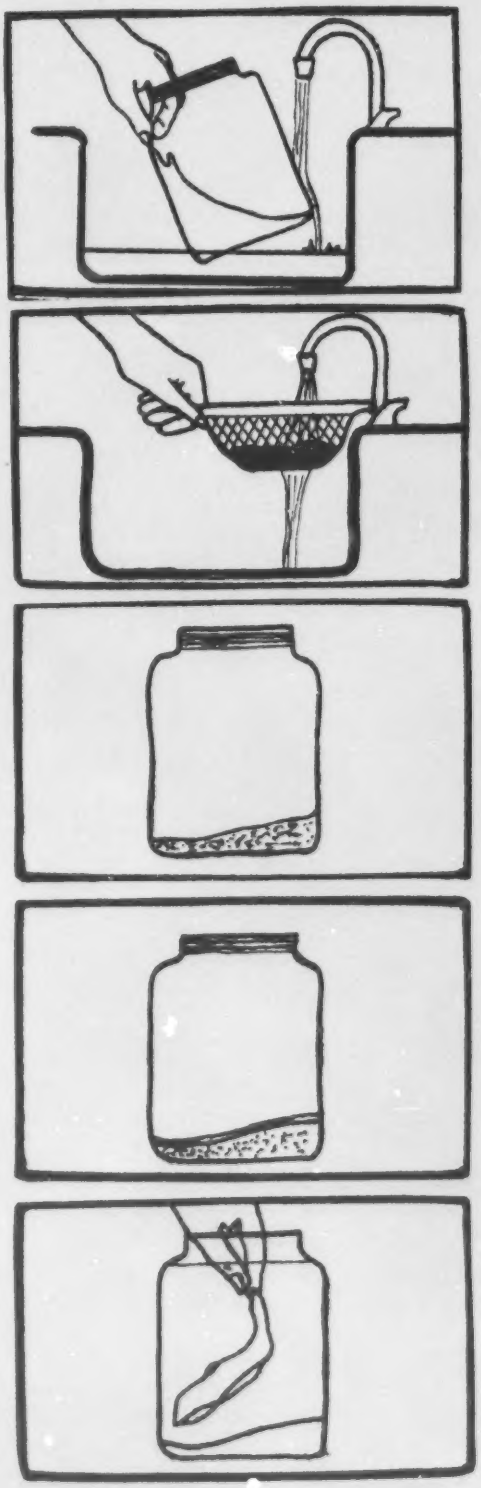
4. Put enough of the washed sand or gravel into the jar so that it is 5 cm deep in the front and 7 cm deep in the back.

5. Place a piece of paper, cut or folded to fit the jar, over the sand or gravel. Pour tap water from a beaker or other container carefully on the paper and fill the jar to within 5 cm of the top.

6. Remove the paper carefully, so that the sand or gravel is not disturbed.

7. Place the jar in a well-lighted spot, but away from direct sunlight. Let the jar stand without a cover overnight. This gives the sand or gravel time to settle and allows the chemical gases the escape into the air. The aquarium should not be moved again.

8. You will be adding living things to your aquarium in the next activity.



Observe your aquarium closely, record your observations and answer the following questions.

1. What makes up the non-living part of your aquarium?

   Many non-living things can be found in an aquarium. Some of these are easier to see than others. Make a chart like the one shown below and list all of the non-living things that you see or you think are in your aquarium. If you can't see something that you are listing, be sure to note that.

NON-LIVING THINGS IN OUR AQUARIUM
1. Gravel
2. Water
3. Air (can't see)
4.
5.
6.
7.
8.
9.
10.

2. How do the non-living parts of your aquarium interact with each other?

   Construct a chart such as the one below and record your findings.

INTERACTIONS BETWEEN THE NON-LIVING PARTS OF THE AQUARIUM		
One non-living part	Another non-living part	How do they interact?
1. Water	Air	Air dissolves in water
2.		
3.		
4.		

FOLLOW-UP DISCUSSION:

Have the groups share their observations, charts, and answers. Keep a list of all the student answers on charts copied on the chalkboard or poster paper. Save these for the next two Activity Blocks.

ACTIVITY BLOCK B -- HOW DO LIVING ORGANISMS AFFECT YOUR AQUARIUM?

MAIN IDEA:

In an ecosystem, living organisms are in constant interaction with each other and their physical environment.

MATERIALS (for each student group):

Two common guppies (get one male and one female) or two minnows (again, one male and one female), an aerator, three or four rooted aquatic plants such as Elodea or eel grass, a handful or floating plants such as duckweed, three or four good sized snails, and brine shrimp.

FOCUS:

Paraphrase: You have set up the non-living parts of your aquarium and have made some observations about their interactions with each other. Now you will add living organisms. Plants and animals that live in the same environment are usually found in groups rather than as individuals. All of the individuals in such a group are called a "population."

Question: How do these living organisms or populations interact with each other and the non-living parts of your aquarium?

PREPARATION SUGGESTIONS:

You need to decide whether to have students obtain their own living materials or whether you will order these orgainisms from a biological supply house or any pet store. If minnows are used, they may be bought at a bait store, but aerators will be needed for each aquarium. Maintain the original group or individual student arrangements and hand out copies of the student directions for adding living organisms to their aquariums. If students ask what the fish, snails, and daphnia will eat, you may tell them that this question will be answered by their observations.

STUDENT DIRECTIONS

1. Collect the following materials for the living parts of your aquarium: two guppies or minnows, three or four rooted plants, a handful of floating plants, three or four snails, and brine shrimp.

2. Place the rooted plants in holes made with your fingers. Put the taller plants at the back and the shorter plants at the sides. Leave the middle and front open, so that you can see what is happening in your aquarium.

3. Place a bag with the fish, snails, and brine shrimp into the aquarium and let it float for an hour. The water in the bag should then be the same temperature as the aquarium water. Now you can put the fish and snails into your aquarium and remove the bag. (Remember, if you are using minnows, then you must have an aerator in your aquarium).

4. Put the floating plants carefully on the top of the water. Use only as many plants as are needed to cover about half of the surface of your aquarium.

5. When you have complete the steps above, cover the top of your aquarium with a screw-on lid or a piece of glass. Do not punch holes in the lid!

Observe your aquarium closely, record the observations and answer the following questions.

1. Now that you have added living organisms, what can be found in the water environment of your aquarium?

A. If you lived in your aquarium, how would you describe your habitat? (Be very specific!)

B. Make a detailed diagram or drawing of your habitat.

C. What makes up the living environment in the aquarium? Make a chart like the one shown below and list all of the living things that you find in your aquarium.

GROUPS OF LIVING THINGS IN OUR AQUARIUM	
Name of Group	Population size of Group

D. Check the population size for two or three days and record this data. What populations in your aquarium have increased or decreased? What might be a reason for the increase or decrease of population size?

2. How do living organisms interact with each other and with the non-living parts of your aquarium? Construct charts such as the two below to record your findings.

INTERACTIONS BETWEEN THE LIVING PARTS OF THE AQUARIUM		
1. Fish	Snails	Snails remove fish waste
2.		
3.		

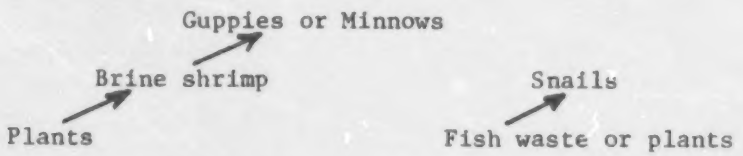
INTERACTIONS BETWEEN THE LIVING AND NON-LIVING PARTS OF THE AQUARIUM		
1. Fish	Water	Swimming Breathing
2.		
3.		

FOLLOW-UP DISCUSSION:

Have the groups share their observations, charts, diagrams, and answers with each other. Add these charts to the ones already on the chalkboard and list the student's answers.)

From the discussions of the charts on the interactions, you can help them to come to an understanding of the meaning of ecosystem (see Key Concepts A and B). Explain that this is a model ecosystem rather than a natural one, and in order to continue without deaths, it must be balanced (i.e., if they leave the cover on, the plants and animals should have everything that they need to survive.) When an ecosystem is balanced, all parts are working well. A simple test to find out if the aquarium is balanced is to remove the cap and smell the water. If the water isn't pleasant smelling or if plants and animals are dying, then the ecosystem is not in balance.

Special reference to the eating relationships or food chain of the living organisms in the student aquariums would be appropriats here. Ask students to describe any evidence of feeding among the organisms. Put their answers on the chalkboard in a food chain structure such as the following:



Focusing on some of the students' observations and answers will lead into Activity Block C, students experiments on factors that affect the balance of their aquarium ecosystems.

ACTIVITY BLOCK C -- WHAT AFFECTS THE BALANCE OF AN AQUARIUM ECOSYSTEM?

MAIN IDEA:

An ecosystem depends upon the balanced interactions among the non-living factors or physical environment (e.g., light, temperature, water, soil) and the living organisms (e.g., plants and animals).

MATERIALS (for each student group):

Two aquariums, a thermometer, a straw, a small strainer or dipping net, a soup ladle or measuring cup, ice cubes, a small glass container, and other materials specified by the students for their self-designed experiments.

FOCUS:

Paraphrase: Each one of you has been observing and studying the interactions of the populations of living organisms with each other and with the non-living parts of a model ecosystem, your aquarium. These interactions must be balanced or the organisms will begin to die.

Question: What living or non-living factors might affect the balance of your aquarium ecosystem?

ACTIVITY 1

TEACHER INFORMATION:

Students will be counting the number of times a fish's mouth and gill covers open and close to determine a change in breathing rate when the temperature of the surrounding water sslowered. When not feeding, the opening and closing of a fish's mouth is a swallowing of water which is expelled through the gills, so the gill covers move as the mouth closes. The dissolved oxygen is taken from the water and carbon dioxide is released. The rate of movement of the mouth and gills is directly related to the temperature of the water. The oxygen demand of a fish is dependent upon the body temperature which is determined largely by the surrounding water temperature. As the temperature is lowered, the body reactions of the fish are reduced. Consequently, the fish's oxygen requirement is also lowered; the volume of water passed over the gill covers and the mouth is reduced. An observer watching these movements should be able to detect these changes.

PROCEDURE:

Provide each student group with a set of materials and copies of the student directions given on the next page. Each group will be testing how a change in water temperature affects the breathing rate of a fish. The breathing rate is determined by counting the number of times the mouth and fill covers open and close in a 15 second time period. The breathing rate is first determined at room temperature and then rechecked after the water temperature has been lowered. Remind the students that the ice cubes should be added gradually to allow the fish time to adjust to the colder water. Also, remind students that the thermometer can break easily, so use them carefully.

STUDENT DIRECTIONS

1. You will need the following materials: one aquarium; a thermometer; a dipping net or small strainer; ice cubes; a small glass container such as a small peanut butter jar, beaker or bowl; a soup ladle or measuring cup; and a straw.

2. Use the soup ladle or measuring cup to take water from the aquarium and put it into the small container. Make sure there is enough water in the container for the fish to swim. Remove a fish from the aquarium with the dipping net or strainer and place it in the small container of water.

3. Take the temperature of the water in the small container. Be sure that the end of the thermometer is in the middle of the container and is not resting on the sides or the bottom. Record this room temperature on the data sheet. (Thermometers can be easily broken, so use care.)

4. Determine the breathing rate of one of the fish in the small container. One way to do this is to count the times that the mouth and gill covers open or close in a 15 second period. Two students are needed to do this -- one to time and one to count. To get a good average number of counts per 15 seconds, take eight counts, then add the counts together and divide by eight. Make a shcart, such as the one below, to average the breathing rate counts and to record your data.

TEMPERATURE

	68°F	45°F
1		
2		
3		
4		
5		
6		
7		
8		
SUM		
AVERAGE		

5. Lower the temperature of the water very gradually or the fish could be harmed! Put one ice cube in the container at a time, so the fish can adjust to the colder water. Stir the water slowly and carefully with the straw to mix the colder water throughout the container. Check the temperature of the aquarium water with the thermometer after each ice cube has melted and the water has been stirred. When the temperature reaches 44-45°F (7°C), immediately remove any unmelted ice cubes. Record the temperature on the data sheet.

6. Use the same method as in Step 3 to determine the breathing rate for your chosen fish and record it on the data sheet.

7. Put the fish back in its original aquarium.

8. Make some conclusions based on your experiment.

9. The whol procedure, steps 1 through 8, can be repeated with the other fish in your aquarium, if you wish.

FOLLOW-UP DISCUSSION:

Each group will present its experiment repost to the rest of the class. Discuss what they learned about the interaction of one non-living factor with a living organism from the experiment that they performed.

ACTIVITY 2

MATERIALS:

One aquarium, additional materials depending upon the students' designs

FOCUS:

Paraphrase: In Activity 1, you determined how one non-living factor, temperature, affected a living organism, a fish, in your aquarium. You will now be designing your own experiments to show what other living or non-living factors affect the balance of your aquarium ecosystem.

Question: What living or non-living factors affect the balance of your aquarium ecosystem?

PROCEDURE:

Each group is to design and carry-out at least one experiment (no more than one experiment for every two aquariums) to see what living and non-living factors might affect the valance of the aquarium ecosystem. The experiment design or plan should be approved by the teacher before eginning the experiments. Ideas for possible factors, or variables to test are:

- --amount of light falling on the aquarium
- --different sources of light
- --number of fish, plants, snails, or brine shrimp
- --punching holes in the lid
- --completely removing one of the populations (e.g., fish, plants, snails, or brine shrimp)
- --adding an aerator, if not already used.

Remind students that they can change only <u>one</u> thing for each experiment and everything else must be the same in the two aquariums. Students can observe: fish respiriation rate (count the number of times the fish open and close their mouths in a designated period of time); movements of organisms (how often, how fast); where organisms are found, plant bubbles or plant colors, etc.

FOLLOW-UP DISCUSSION:

Each group will present its experiment report to the rest of the class. Discuss what they learned about water ecosystems from the experiments that they performed and also what they learned about designing and conducting experiments.

EXTENSION:

Illustrating short stories or poems about their aquarium (perhaps from the snail or fish's point of view) would be good extensions to the aquarium activities.

A FIELD TRIP

A field trip to a lake or stream is a wonderful opportunity for students to apply what they have learned in the lab to the "real world." Students gain a greater appreciation for their role in nature by the study of nature in its natural setting.

However, effective field trips take a great deal of advance planning if they are to be the best possible learning experiences. This unit will provide you with the information necessary to have an outstanding experience outdoors.

I. SOME BEGINNING QUESTIONS

A. What do I hope to accomplish?

There are a variety of reasons for going on a field trip—not all of which are good reasons. Field trips are best used to relate experiences in the lab or classroom to the "real world." Lab experiments, while "fun" for students, are often viewed as being separate from anything that goes on in the world. Field trips help to bridge this gap between the isolated experiments done in the lab and the way that these concepts fit together to help us understand the grand scheme of nature. However, for the field trip to be worthwhile, sufficient advance planning is needed.

B. Where shall we go?

An understanding of what you hope to accomplish will help you to decide where to go and what to do. On the simplest level, a trip to a local lake or pond (and there are few places in the "Land of 10,000 Lakes" without a nearby pond) will provide a wealth of information and experience. Though more expensive, a trip to one of the larger lakes allows students to experience the effects of a larger aquatic ecosystem. You will need to consider the amount of time available and how much you can afford to spend. Nature centers may have programs available to help at a reasonable cost (or even sometimes at no cost).

C. What plans all I need to make?

The following is a check list of advance planning that you may need to consider:

- Availability of facilities (if reservations are necessary)
- Permission of school administrators and coordination with other teachers for release of students.
- Transportation
- Parent leaders (probably at least 1 per 8 students for maximum safety near water).
- Parent permission slips (be sure to indicate where the students plan to go and any special clothing that they will need).
- Materials for working in the field (plans are given in the next section)
- Lab sheets, record books, etc.

D. What materials will I need?

Collecting jars (baby food), cord, metal lid, eye bolt, washers, nuts, small bottle, nails, waterproof tape, cork, screw eye, 1" x 1" pine wood, window screen, wire loop (or banding iron), nylon stockings, rubber bands, wooden dowel, heavy wire (e.g., coat hanger wire), thermometer, large nails, magnifying glasses.

II. PREPARING STUDENTS FOR THE TRIP

There are many things that can be done ahead of time to plan for a successful field trip. Maps of the area are useful in orienting students to the site (better yet would be slides that you might have taken on a previous trip). Excellent maps are available from:

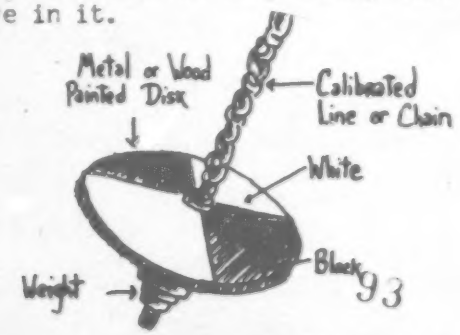
Branch of Distribution, Eastern Region
U.S. Geological Survey
1200 South Ends Street
Arlington, VA 22202

These maps can be used to plan out a study scheme. Student groups can be made responsible (as their group task) for different parts of the lake area.

You will also want to have students prepare some equipment for use in their study. Plans for some of this equipment are given below.

1. SECCHI DISK

A secchi disk is used for measuring the clarity of the water. You will need a large (5-6" diameter) can lid, an eye bolt, two washers, two nuts, and 20 feet of rope. Paint the disk (using water proof paint) black and white as shown in the diagram. Drill a hole through the center of the lid and attach the bolt. Tie the rope to the eye bolt and make a knot in the rope every foot. These knots will be used to measure the depth. To use the secchi disk, stand on the edge of a pier or lean over the edge of a boat. Drop the disk into the water and slowly lower it until it just disappears. Record this depth. Raise the disk until it just appears and record this depth. Take an average of the two depths as the reading. This gives an indication of how far light can penetrate. Since plants need light to live, this depth is an indication of the productivity of the lake. In other words, if a lake is very cloudy then not as many plants can live in it.

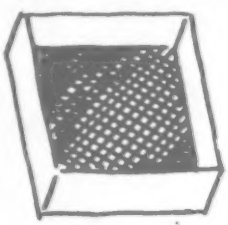


2. WATER SAMPLER

Tie several nails or weights to the outside of a small bottle to make it heavy. Insert a screw eye into a cork the proper size for the bottle. Tie a cord around the neck of the bottle and then leaving some slack, knot the cord to the eye (see diagram). Knot the cord every foot. To use the water sampler, gently lower the bottle into the water until it reaches the desired depth (as measured by the knots on the cord). Pull the cord sharply to remove the cork. When the bubbles have stopped, pull the bottle to the surface and pour some of the water into a small sample bottle.

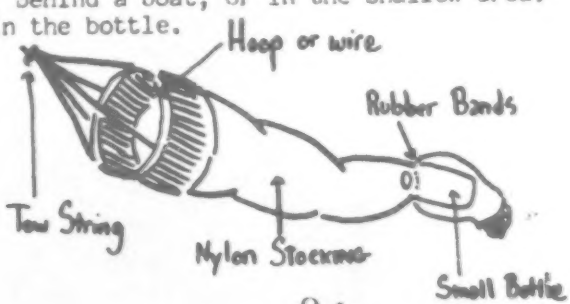
3. SORTING SCREEN

A sorting screen is used for filtering sand and gravel on the beach. Make a wooden frame of 1" x 1" board 12" long by 6" wide. Attach to the frame a piece of window screen (the large mesh size will work best). Be sure to fold up the edges to get a secure fit. To use the screen, place a sample of sand into the screen and shake the screen back and forth to sift the sand. This works best with two people.



4. PLANKTON NET

Make a circle out of wire or bending iron. Attach a nylon stocking to the circle. Toward the end of the stocking insert a small bottle and secure the stocking to the mouth of the bottle with rubber bands. Tie strings to the opening of the stocking to use as a tow line. To use the plankton net, drag the net through the water off the end of a pier, behind a boat, or in the shallow area. Collect plankton in the bottle.



5. DIP NET

A dip net can be made in similar manner. Drill a hole in the end of a wooden dowel and insert two ends of a heavy piece of wire. Form the wire into a circle and attach a piece of nylon stocking. Use this net to scoop up small organisms by hand.

6. THERMOMETER

Attach a cord to a thermometer. Knot the cord every foot. To use drop the thermometer to the desired depth and leave it for several minutes. Draw it up rapidly and read the temperature quickly.

7. COLLECTING JARS

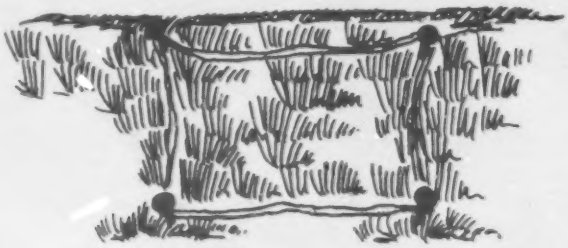
Baby food jars work well. Bring along tape for labeling.

III. THE FIELD TRIP

Divide the students into groups of three or four (depending on the number of adult leaders). There should be a parent leader for every two groups at least. These two groups will work near each other so that the one leader can supervise both groups simultaneously.

ACTIVITY 1

Using four large nails and 4 yards of cord, stake out a square plot of land on the shore, measuring 1 yard in length on each of the sides. Record everything that you observe within that plot of land. If you don't know the name of something, describe it the best you can.



ACTIVITY 2

Look at the material right on the edge of the water. What is it made of (pebbles, sand, mud, etc.)? What does this tell you about the way that the lake was formed?

ACTIVITY 3

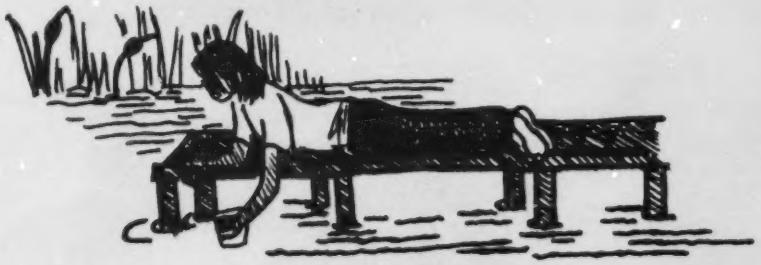
Look at the water. Do you see any plants or animals? Describe what you observe.

ACTIVITY 4

Collect a small amount of pond water in a jar. Using a magnifying glass, look closely at the water. What do you see?

ACTIVITY 5

Take temperatures at various spots on the lake. If there is a pier or a boat available, walk out on it and take measurements of temperatures at various depths. Does the temperature change? Take temperatures at various points along the coast. Are there any differences? What might explain this?



ACTIVITY 6

Standing on a pier (or leaning from a boat) drop the secchi disk into the water until it just disappears from sight. Record the depth from the number of knots. Pull the disk up until it can just be seen. Record this depth. Find the number which is halfway between these two numbers. Record that number as the depth where the disk disappears from sight.

ACTIVITY 7

Standing on the pier or in a boat, collect a water sample from near the bottom of the lake using the water sampler. Seal and label the jar with the data, location of the sample, and names of the students in the group.

ACTIVITY 8

Drag the plankton net along the side of the pier, behind a boat or just off the shore line. Seal and label the jar with the date, location, and names of the students in the group. Also, label the jar "plankton."

ACTIVITY 9

Using the dip net, sift a net full of water. Do you see anything? Repeat several times and record observations.

ACTIVITY 10

Using the sorting screen, sift through some of the beach material. Do you see anything? Collect the objects that are left behind in the screen. Make a list of observations about these objects.

IV. BACK IN THE CLASSROOM

Spend some time discussing with the students what they learned from the experience. Compare observations from the various activities and different groups.

ACTIVITY 1

Place the water samples collected in the sunlight. Check them every day using a magnifying glass. Do you see any difference between water collected at the top of the lake and water collected at the bottom of the lake.

ACTIVITY 2

Make diagrams showing the various things that you see in the water.

ACTIVITY 3

Make a drawing of the lake showing your feelings about the field trip.

ACTIVITY 4

Write a poem or a short paragraph about your field trip experience.

ACIDS AND BRINE SHRIMP

MODULE OVERVIEW

This module focuses on the effects of acids upon a small marine invertebrate. Students will observe the hatching and behavior of brine shrimp under normal conditions. The effects of acids on the prevention of hatching is intended to demonstrate the damage that acid rain does to living organisms.

APPROXIMATE TIME: 1-2 weeks

KEY CONCEPTS OF THE MODULE:

A. Proper conditions of salt concentration and temperature are required for brine shrimp to hatch.
B. Brine shrimp respond to light.
C. Acids will prevent the hatchng of brine shrimp.

MATERIALS NEEDED FOR THE MODULE:

Brine shrimp, shallow pans, non-iodized salt, cardboard pieces, eyedroppers, magnifying glass, light source, paint mixing tray (or egg carton), plastic wrap, vinegar.

INTRODUCTORY ACTIVITY

MATERIALS:

Brine shrimp eggs (available from a pet store)

PROCEDURE:

Place some brine shrimp eggs on a piece of paper. Ask the students to observe some of them and to guess what they might be.

ACTIVITY BLOCK A--WHAT CONDITIONS ARE NECESSARY FOR BRINE SHRIMP TO HATCH?

MAIN IDEA:

Proper conditions of salt concentration and temperature are required for brine shrimp to hatch.

MATERIALS:

Each student group will need:
Brine shrimp, shallow pan, non-iodized salt, cardboard piece, eyedropper, magnifying glasses.

FOCUS:

Paraphrase: We looked at something and you made guesses as to what it might be. Let's see if we can find out what it might be by putting it in water (if you have time you may wish to ask the students to give you suggestions as to ways of finding out what the material is and then test those suggestions that are feasible). It may take several days so we will have to watch daily.

Question: What happens eventually to the substance when we put it into water?

ACTIVITY 1

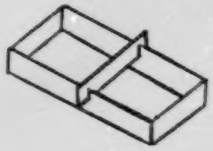
TEACHER PREPARATION:

Brine shrimp need salt water in order to hatch. A proper solution can be made by mixing 8 teaspoons of non-iodized salt with 1 quart water. (You will probably need to make at least a gallon of solution for a class of 30 students. If you have storage space and a container, it is best to make this all at once.) Use distilled water, or tap water that has set for 24 hours to allow the chlorine to escape. The temperature should ideally be between 70 and 80 degrees Fahrenheit. If it is colder, the eggs take too long to hatch. If it is hotter, the oxygen concentration begins to drop too low for the brine shrimp to survive.

PROCEDURE:

Divide the class into groups of three or four. Provide each group with a shallow pan and some salt water.

Cut a piece of cardboard 2 inches longer than the width of the pan and about an inch wider than the depth of the pan. Slot both ends of the cardboard so that it will fit over the sides of the pan leaving about a 1/2" clearance at the bottom (see diagram).



Pour enough salt water into the pan to fill it 1/2 inch. Sprinkle about 1 teaspoon of the mystery material (brine shrimp eggs) into the water at one end of the pan. Place the pan in a spot where it will be warm and undisturbed (but not in direct sunlight).

After 24 hours, observe the pan. (TEACHER NOTE: If small moving objects are seen--white to red in color--then the brine shrimp have hatched. To separate the shrimp from their egg shells, have student groups place a piece of cardboard over the end of the pan with the eggs to cut off the light and place the other end in the light. Soon the shrimp will move toward the light. They can then be transferred to a clean container of salt water with an eye dropper.)

Observe the mystery material with a magnifying glass (or microscope if available). Describe in words and draw a picture of what you see.

FOLLOW-UP DISCUSSION:

Have student groups report their observations and share their drawings. Have them infer whether the original material was living or non-living. Have them explain what led them to this conclusion. Have them tell you what type of living material this might be (e.g., plant, animal, fish, etc.) After they have guessed, tell them that they have just observed the hatching of Brine Shrimp. Have them label their pictures "Brine Shrimp" and put them up on display.

ACTIVITY 2

Once your class has succeeded in hatching the brine shrimp, you may wish to have them look at some of the factors controlling brine shrimp hatching. Have the students suggest some of the things that could be tested which might affect brine shrimp hatching. They may wish to consider:

a. temperature (to a limited extent, the higher the temperature, the faster they hatch. However, above 85 F the amount of oxygen in the water drops below the level where brine shrimp can survive.)
b. amount of salt in the water.
c. crowding of brine shrimp.
d. amount of light.

NOTE: If you wish to keep your brine shrimp for an extended period of time, they should be fed a small amount of dry baker's yeast every couple of days. Don't overfeed them or the yeast will begin to grow in the water and cause the water to become fouled.

FOLLOW-UP DISCUSSION

Have student groups share the experimental reports and then discuss their implications as a class.

ACTIVITY BLOCK B--HOW DO BRINE SHRIMP REACT TO LIGHT?

MAIN IDEA:

Brine shrimp respond to light by moving toward the light.

MATERIALS:

Brine shrimp, light source (e.g., flashlight), shallow pan, cardboard divider, salt solution, cardboard card (to cover half of the shallow pan)

FOCUS:

Paraphrase: In a previous activity we saw that the sand-like materials were really the eggs of a small water creature. In this activity we will look at the way that this organism responds to light.

Question: How do brine shrimp respond to light?

PROCEDURE:

Ask student groups to design an experiment to answer the question. The procedure below is one approach that they might choose.

Clean out a shallow hatching pan. Place the cardboard divider across the pan, leaving 1/2" clearance at the bottom. Place 1/2" of salt solution into the pan. Pour a container of brine shrimp (which have been separated from their egg shells) into one end of the pan. Immediately cover that end with a cardboard card. Shine a light at the other end. After several minutes, cover the other end with the cardboard card and shine the light at the opposite end.

EXTENSION: Other Variables Affecting Brine Shrimp Behavior

Ask the students, "Can you think of anything else that adult brine shrimp might respond to?" Allow the student groups to test their own ideas by designing experiments. They may suggest such things as:

1. temperature (put an ice cube in one end),
2. food (put some yeast in one end),
3. sound (strike a tuning fork at one end).

They should then write up an Experiment Report as in Activity Block A--Activity 2.

ACTIVITY BLOCK C--HOW DO ACIDS AFFECT BRINE SHRIMP?

MAIN IDEA:

Acids will prevent the hatching of brine shrimp.

MATERIALS:

Each group will need: White plastic paint mixing tray or egg carton, brine shrimp, salt solution, vinegar, eyedroppers, plastic wrap.

FOCUS:

Paraphrase: In the last activity we saw that brine shrimp respond to light. In this activity we will look at the way that acids affect the hatching of brine shrimp.

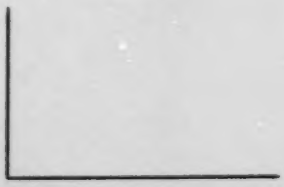
Question: How do acids affect the hatching of brine shrimp?

PROCEDURE:

Provide each student group with a set of materials.

Instruct the students to fill each container of a paint mixing tray or egg carton with salt solution. They should mark the first container "no acid." Each subsequent container should be marked "1,2,3 . . . etc." In the container marked "1," have them place 1 drop of vinegar, in the container marked "2," 2 drops and so forth until all are treated. A small amount of brine shrimp eggs should be sprinkled over each container. Have them lightly cover with plastic wrap to slow down evaporation. (NOTE: With such small volumes of liquid you will have to carefully monitor the evaporation. If containers do appear low in volume, refill them with distilled water.)

After 24 hours, ask students, "What do you observe?" Have students count the number of hatched brine shrimp with a magnifying glass. This should be plotted on a graph.



Ask the students, "How does acid affect the ability of brine shrimp to hatch?"

Students may be interested in looking at the way in which acids affect the behavior of adult brine shrimp. Have them put a few drops of salt water on a glass plate (or piece of waxed paper). Using an eyedropper, a brine shrimp should be on the water. Have the students observe the motion for awhile. Ask the students, "How rapidly does the brine shrimp move around the drop?"

Have them carefully place a drop of vinegar to one side of the salt water drop so that it just touches. Ask the students the following questions:

"What effect does this have on the brine shrimp?"

"Does the brine shrimp move toward the vinegar or away?"

"What does this tell you about the effects of acid rain on living things?"

EXTENSION

UNIT

THE ACID RAIN GAME

TEACHER BACKGROUND

What has left over 200 lakes in the Adirondack Mountains of New York barren of fish and threatens to do the same to the lakes of the Boundary Waters Canoe area in the northern regions of Minnesota? What is destroying the ancient temples of Greece? What has become the second most serious environmental problem in the United States and is also becoming a worldwide problem? Rain. The substance needed by all plants and animals in order to survive has become, in a special form, a potential killer. Acid rain, if unchecked, has the potential to destroy not only lifeforms, but also many of the monuments of mankind constructed throughout the ages. But, what is "acid rain"?

All normal rainfall is slightly acidic. This acidity is the result of the combination of carbon dioxide in the air with the rain to form carbonic acid, the same substance found in soda pop. In modern societies, an imbalance between the normal acidic levels and an overload is being created. Sulfur dioxide produced by such activities as burning coal and nitrogen oxides from automobile exhaust is increasing at such rapid rates that when they combine with the moisture in the air, sulfuric acid and nitric acid are formed. These acids are then returned to the earth during normal rainfall periods as acid rain. Increased acidic concentrations in lakes can result in the eventual extinction of all life within the lake.

These sulfur dioxide and nitrogen oxide gases do not recognize state or even national boundaries. Sulfur dioxide produced by a power plant in one area may be carried thousands of miles to be dumped on another area. The problem of identifying a pollution source many thousands of miles away, compounded with international disagreements, makes regulation very difficult.

It is increasingly important, therefore, that people become aware of acid rain and its effects. As present and future decisions about the environment are considered, it is important that elementary age students come to grips with the problem. It was for this reason that the Acid Rain Game was made.

ACID RAIN GAME: DESCRIPTION

The Acid Rain Game is a board game designed to help students explore the relationships among the production of power, the making of a profit, and the death of fish from acid pollution. Students are given opportunities to make important decisions about the production of power and to observe the results of decisions.

The game functions best as a springboard activity to the study of acid rain problems. As such, it serves to arouse student interest in the topic and focus attention on key issues. The game serves as the first step in the study of acid rain to initiate some questions which will be answered later during the students' study.

FOLLOW-UP DISCUSSION:

Since this game is designed as a springboard activity, it is important to follow up the game with some additional activities looking at the problems of acid rain. The following questions may be used to get the students thinking about some of these environmental problems.

1. Has either country really "won"?
2. What happens when one country doesn't have enough food to feed its people or enough power to run its industries?
3. If you heard that a U.S. power plant was polluting the lakes of another country, do you think that the U. S. power plant should stop polluting even if it meant that you would have less power or that it would cost more? Why or why not? (Have the students list the consequences of continued operation versus the consequences of shutting down the plant.)

EXTENSION:

You may wish to extend the activities outside of the classroom by having the students research the issue of acid rain and then prepare an information brochure describing the problem of acid rain which they could share with other students in the school as well as with their parents.

FOR MORE INFORMATION:

Information Booklet on
International Joint Commission
Great Lakes Regional Office
100 Quellette Avenue
Windsor, Ontario N9A 6T3
(Also ask about their slide/tape show "Promises to Keep")

The Case Against the Rain
Ministry of Government Services
Central Purchaseing Service Branch
Parliament Buildings
Toronto, Ontario M7A 1N8

Research Summary: Acid Rain
EPA-500/8-79-028
United States Environmental Protection Agency
Ed 674
Washington, D. C. 20460

(The above publications are provided free of charge.)

THE ACID RAIN GAME

(Student Instructions)

The Acid Rain Game is for two players. One player represents Northland and the other player represents Southland. (See Figure 1 for the diagram of the game board.) Both countries have several lakes along their border, and both countries have power plants along their border. The lakes are important because they provide fish, a major part of the diet for citizens of Northland and Southland. The power plants are important because they provide the energy to run the industries in the country. The problem is that the power plant uses coal containing sulfur. When this coal is burned, it turns into the chemical sulfur dioxide. Sulfur dioxide combines with rain to form acid rain. Acid rain can kill fish.

Setting up the Game Board. Cut out the playing board and spinners and glue them to a heavy piece of cardboard. Poke a hole in the center of each spinner and in the tip of each of the factory smokestacks. Unbend 4 paper clips to serve as spinners or smokestacks (see diagram).

Unbend 2 paper clips to serve as pointers for the spinners (see diagram).

Make paper money in $5,000 and $10,000 denominations. Cut out the plumes and punch a hole through one end of them.

Starting the Game. Each player starts the game with $100,000 distributed as follows: five $10,000 bills and ten $5,000 bills. In addition, each player starts with 40 fish (fish may either be cut out of paper or some token may be used to represent the fish). These 40 fish are to be distributed among the nine lakes in each country. To begin, each player spins the fish kill spinner to determine who should go first. High spin goes first.

Playing a Round. Each round represents one day. Since the weather can change each day, the first task is to spin the wind direction spinner. On each succeeding round, the task of spinning for wind direction alternates between players. There are two possible outcomes: the spin may be an east or a west spin, or the spin may be a north or a south spin.

East-West Spins. If an East or a West direction is indicated, then it means that each country's factory is polluting its own lakes. Each player decides how much power will be produced and hence how much pollution each power plant is giving off. (You will need to balance the fact that using more power results in earning more money, but also in the possibility of losing more fish.) Players may choose to run their power plants at full power, at 60% power, or at 30% power.

Full Power. At this level, the power plant is operating at full power and also is putting out a full amount of pollution. This is represented by the largest plume. Since the power plant is operating at full power, it means that you are earning money from selling the power to customers, so you collect $20,000 from the bank. Since this produces the greatest amount of pollution, the trade-off is that you have to spin the fish kill spinner three times and total the sum of the three spins to determine the number of fish killed.

60% Power. At this level, the power plant is just putting out enough power to "break-even." You neither gain nor lose money. The medium sized plume represents the pollution from this amount of power. The trade-off is that you only have to spin the fish kill once to determine the total number of fish killed.

30% Power. At this level, the power plant is not producing enough power to meet the country's needs, so you have to buy power. This costs $20,000 and it is paid to the bank. The short plume is used for this level of power. Since a minimum of pollution is being produced, you don't have to spin for fish kill at all.

After each player has decided on the power output and paid money (if at 30% power) or collected money (if at full power), the appropriate plume is chosen and placed on the pin through the factory with the tail in the direction indicated by the wind.

North-South Spins. On a North or a South spin, there is an additional problem. In this case, pollution is going across national boundaries. In other words, one country is polluting the other. For example, on a south wind spin, Northland is polluting Southland. Before deciding power, it is necessary to hold an International Joint Commission hearing (between Northland and Southland). In this case, the country being polluted can attempt to bargain with the polluting country to use less power. For example, the country being polluted may offer the polluting country $30,000 to use only 30% power. If a deal is made, then the polluting country places that plume on its smokestack. (NOTE: If the country agrees to 30% output, it must still pay $20,000.) If no deal is made, then the polluting country can decide any amount of power. After the polluting country spins, then the polluted country spins to determine how much it will pollute itself. Remember, negotiations go both ways and while today it is a south wind, tomorrow it could be a north wind.

Fish Kill. After the direction of pollution has been determined, each player spins the fish spinner to determine how many fish will die. For full power output, the spinner is spun three times and the number of fish killed is the sum of the three spins. For 60% power output, the spinner is spun once and that number of fish removed from lakes covered by the plume. For 30% power output, there are no fish killed. If there aren't enough fish in the lakes, then fish can be moved from a lake directly next to the one without fish. If there aren't enough fish available, then that person is out of the game.

Ending a Round. At the end of each round, players may choose to move their fish around (but fish can only be moved to lakes next to each other) or restock with more fish (each fish token representing 1,000 fish costs $5,000).

Ending the Game. Play continues, alternating the wind direction spin each round until one player goes broke or one player loses all of the fish. At this point the game ends.

ACID GA

Starting the Game

Each Player starts with $100,000

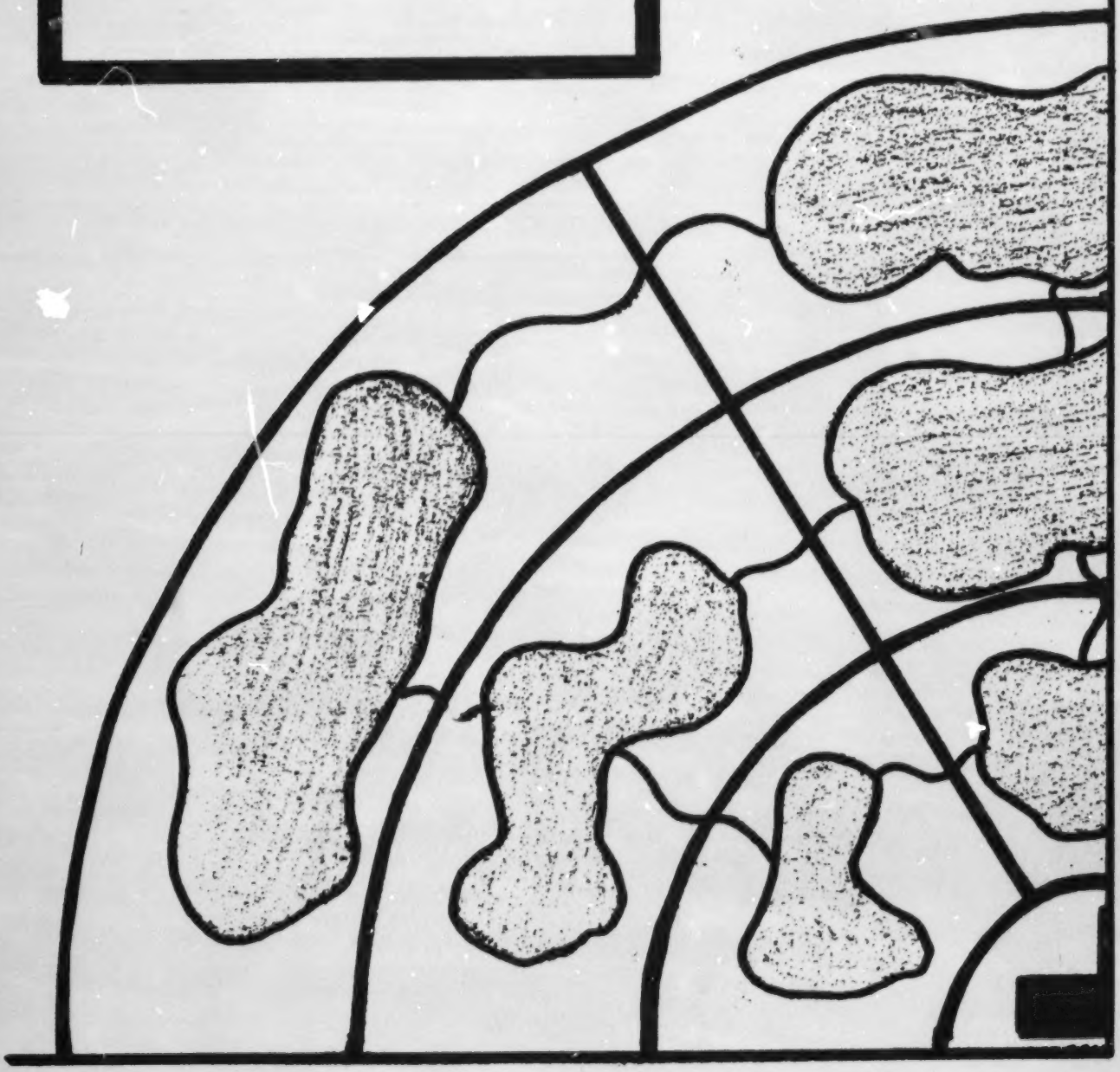
5 - $10,000 bills

10 - $ 5,000 bills

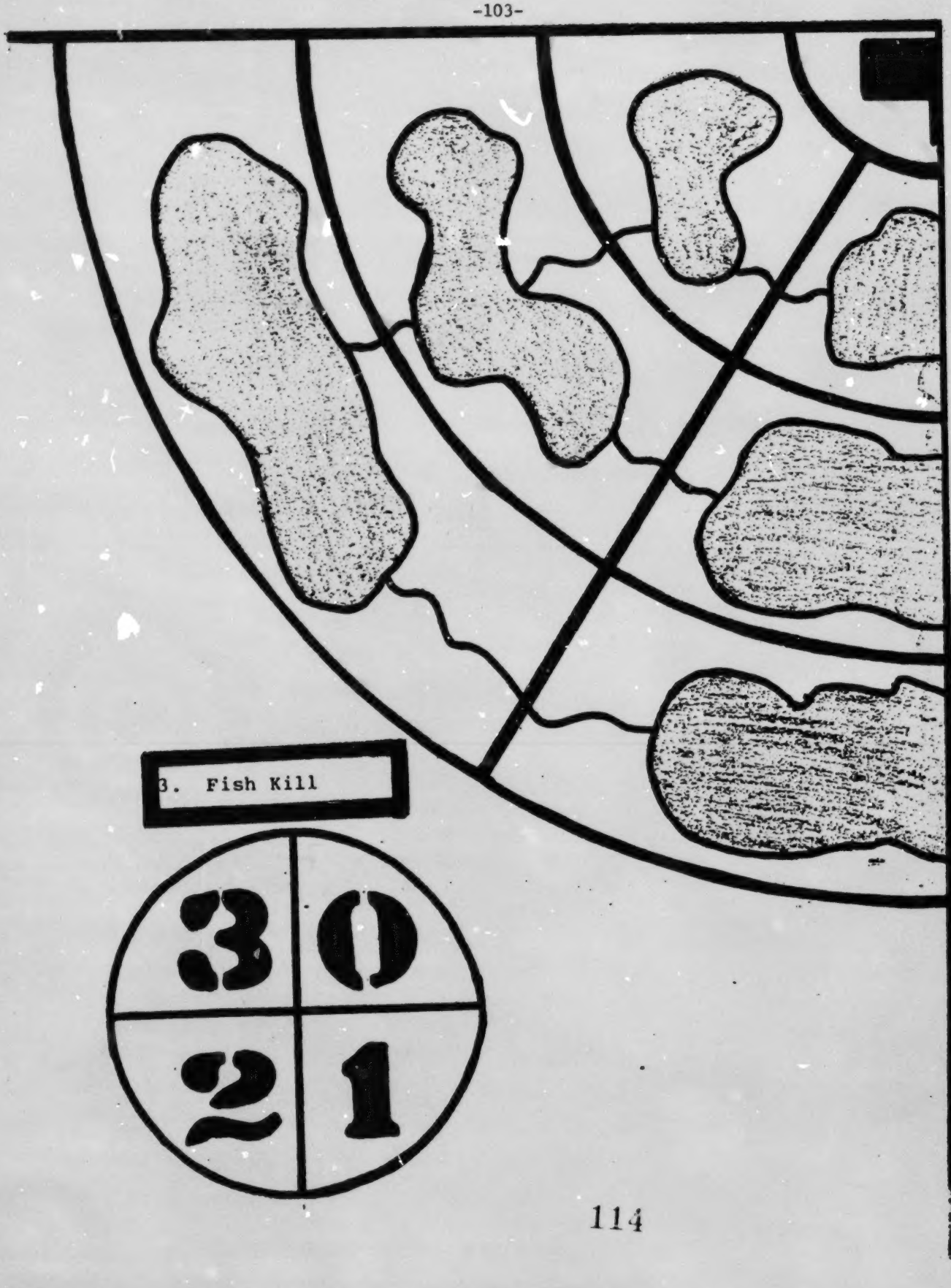
Each Player starts with 40 fish

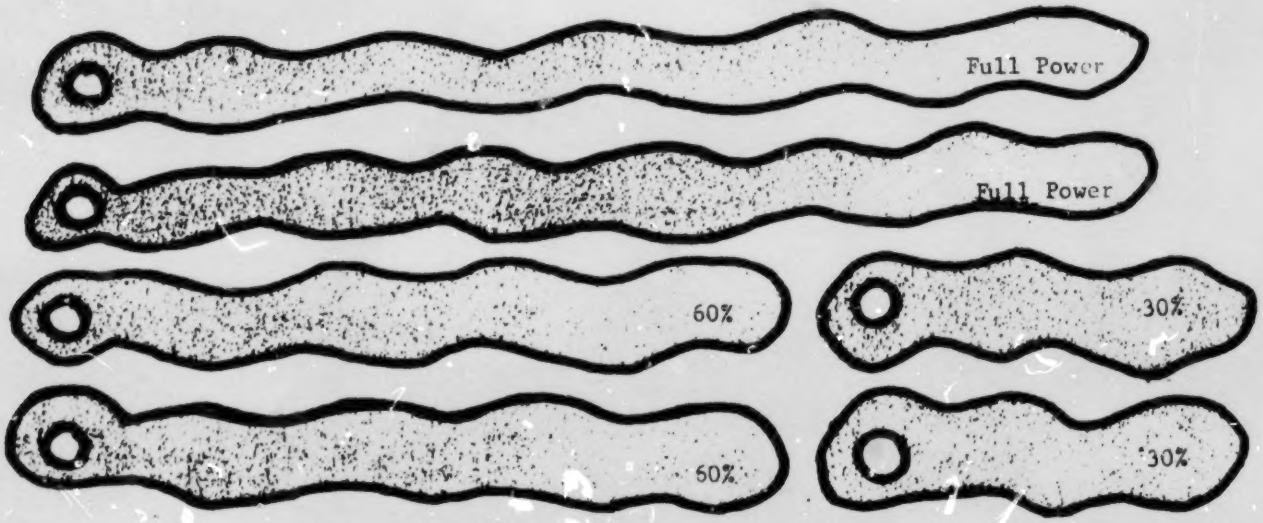
Restocking

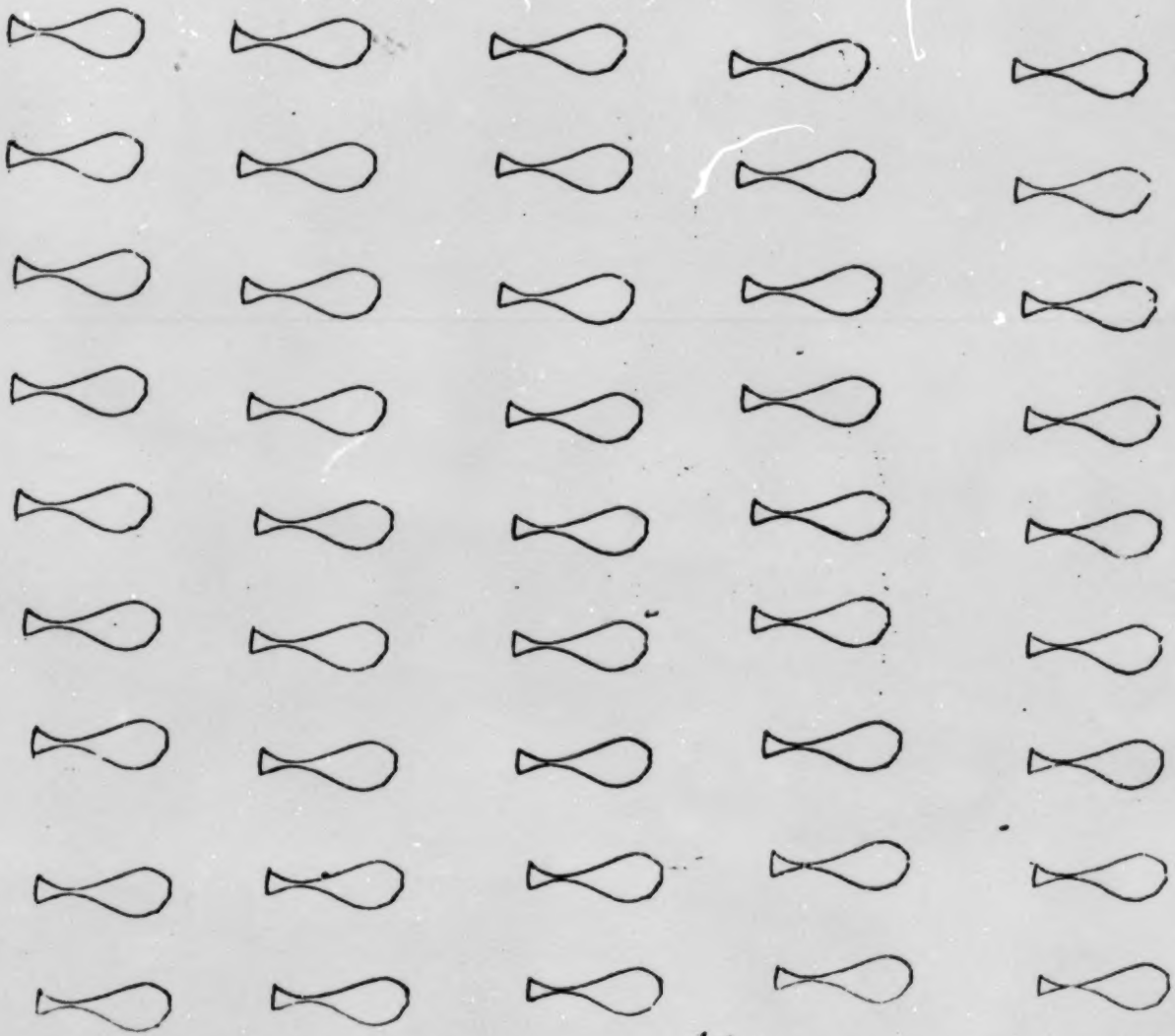
Each fish (representing 1,000 fish) costs $5,000

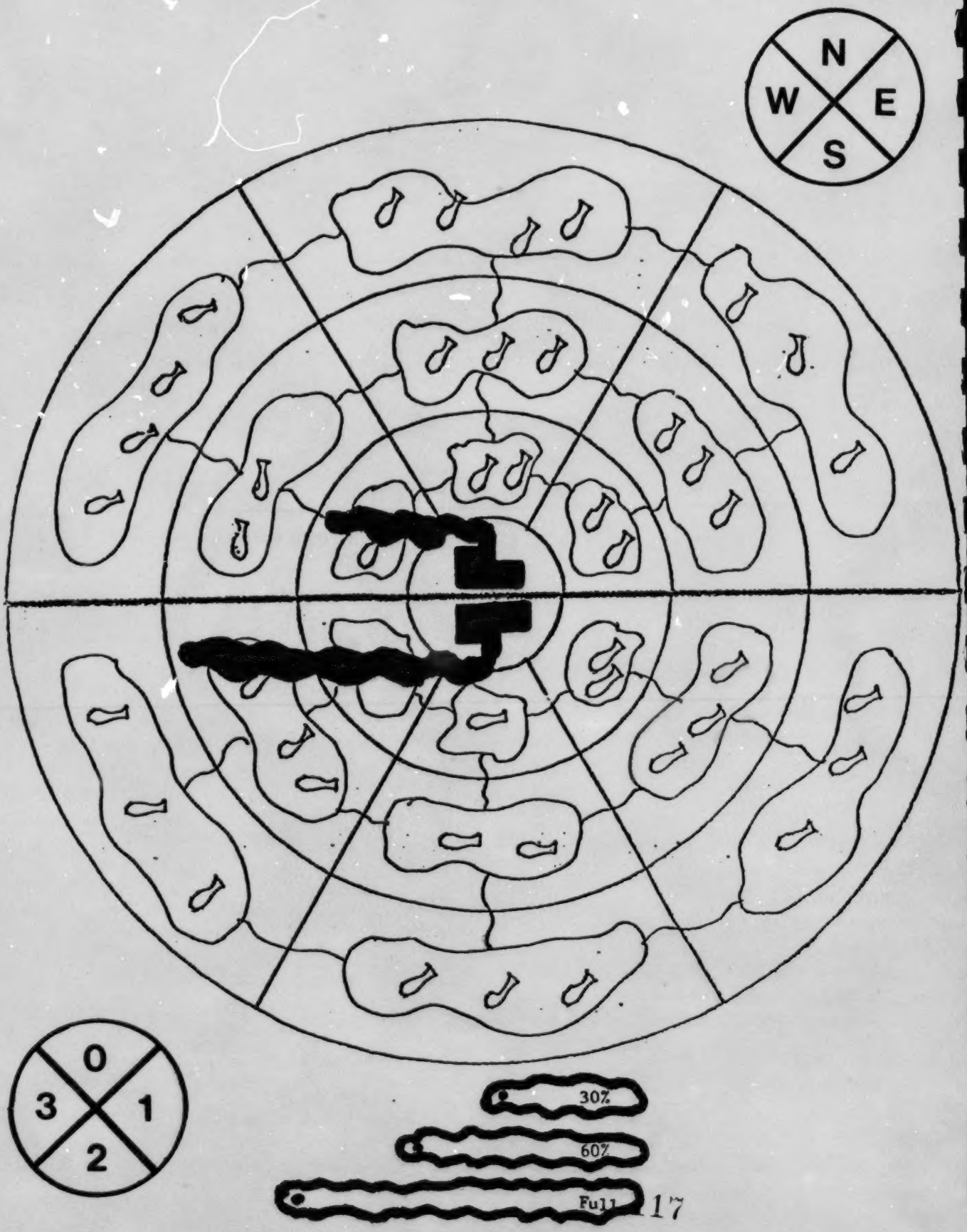


1. Wind Direction


3. Fish Kill
3
0
2
1


Full Power
Full Power
60%
30%
60%
30%





17

A BWCA CASE STUDY

Teacher Information

Teacher Information Page

A B.W.C.A. Case Study

The following materials allow students to simulate the decision-making process involved in determining the types of use for the Boundary Waters Canoe Area in northeastern Minnesota. Students will portray various special interest groups who will present their view to a senate advisory committee. That committee will be responsible for deciding how the BWCA should be used based on how convincing the special interest groups make their presentation.

The following list gives a plan for carrying out the simulation.

TASK A: BACKGROUND — Individual Activity

TASK B: ANALYSIS — Individual or Small Group Activity

At this point you may wish to discuss the two congressional bills with the students to be certain that they have a clear understanding of the issues.

TASK C-PART I: STRATEGY SESSION — Small Group Activity

TASK C-PART II: SENATE ADVISORY COMMITTEE — Small Group Activity

Divide the class into 5 groups. Five of the groups will be assigned to a special interest group role. A sixth group should be assigned by selecting one student from each of the 5 groups to serve on the Senate Advisory Committee.

PRESENTATION OF GROUP PLANS — Large Group Activity

REPORT FROM SENATE ADVISORY COMMITTEE — Large Group Activity

DEBRIEFING — Individual and Large Group Activity

POSSIBLE SCHEDULE OF ACTIVITIES

DAYS (45 Minutes - 1 Hour Each Day)

1	2	3	4	5
TASKS A & B	TASK C	TASK C & PREPARATION FOR PRESENTATION	PRESENTATION	COMMITTEE RESULTS & DEBRIEFING

REMEMBER: The teacher plays an important role in this simulation. The teacher functions as an orchestra leader, constantly giving directions and advice, while allowing the students to find their own ways of working through the issues. Be sure to follow up the activity with the debriefing. A guide is found at the end of these materials.

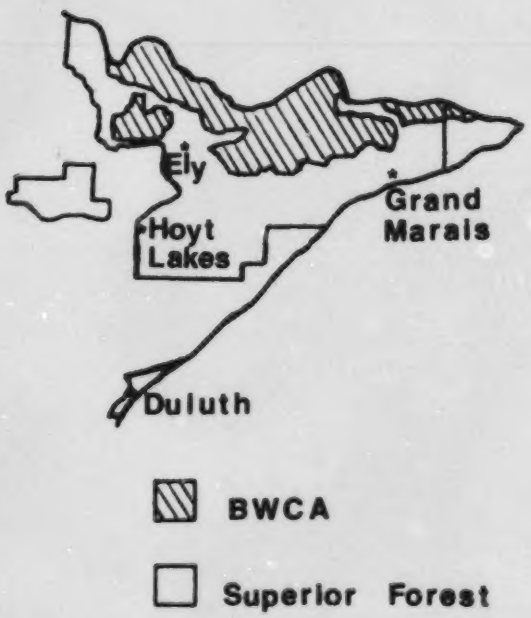
INTERESTED STUDENTS: You may wish to invite interested students to explore this topic in more depth by looking at the decisions that were made by the US Congress with regard to the BWCA. In this regard, the Burton-Vento Compromise Bill of 1978 would be useful.
Also students may be interested in exploring some of the other federal parks and wilderness areas.

OUTCOMES

At the end of this activity, students should have a better understanding of the
a. physical, economic, and social characteristics of the Boundary Waters Canoe Area and how these factors affect the way that the region is used;
b. various points of view represented by the Wilderness Act and the Multiple Use Act;
c. process of preparing a presentation in order to convince someone of their position;
d. necessity for compromise in the legislative process in order to accommodate the majority of special interests.

TEACHER BACKGROUND

Managing Minnesota's Environment
A Newsletter for Teachers
Number 17, April 1978



PROS AND CONS ON USE OF BOUNDARY WATERS CANOE AREA

The use and management of the Boundary Waters Canoe Area has been a controversial issue for many years and will probably continue to be so for years to come. This issue of the newsletter contains excerpts from articles and reports about several aspects of the controvery. The newsletter, in an effort to show both sides of these aspects, makes no attempt to decide the issues or pass judgment on the statements made by the original authors of the articles.

William Jokela, research assistant and graduate student, University of Minnesota, Department of Soil Science, spent hours assembling the information. Much valuable and pertinent material had to be omitted in the process of excerpting articles in order to keep within the space limitations of this newsletter. Readers are advised to consult the original articles for more complete background information.

This is the concluding issue of Managing Minnesota's Environment as an educational effort of the Agricultural Extension Service, University of Minnesota. Mailing costs and the need for extension to shift its educational resources to areas not being met by other efforts are the primary reasons for concluding the series.

Copies or reprints of several previous issues of the newsletter are still available and may be requested in quantities until supplies are exhausted. Please send all correspondence concerning this newsletter to Clifton Halsey, Extension Conservationist-Soils, 16 Soil Science Building, 1529 Gortner Ave., University of Minnesota, St. Paul, Minnesota 55108.

WHAT IS THE BOUNDARY WATERS CANOE AREA?

The Boundary Waters Canoe Area, located in northeastern Minnesota, is the largest National Wilderness Area east of the Rocky Mountains--slightly over 1 million acres in size. As a vast area of inter-connecting waterways, amidst virgin conifer forests, it is our only lakeland wilderness and unique in the National Wilderness System . . . it stretches for more than 100 miles along the Minnesota-Ontario border and supports unique northern fish and wildlife populations . . . Together with its sister area, the million acre Quetico Provincial Park in Ontario, where all logging and most motorized recreational uses are already prohibited, these two areas comprise one of the finest wilderness regions on the continent.

-Friends of the Boundary Waters Wilderness

Peaceful as this description sounds, the history of this wilderness area has been one of almost continual controversy. The area has seen such diverse activities as canoeing and camping, motor boating, cross-country skiing, snowmobiling, wilderness research, and timber harvesting. Such varied use of the BWCA stems from different purposes the area has served for two groups of users, as desribed by Congressman James Oberstar (Congressional Record, Aug. 5, 1977):

"To some the BWCA is treasured for its scientific educational and primitive values, an opportunity for the urban dweller to escape to the solace and solitude of a remote land where one can experience the adventure of discovery, see the primeval land as man first saw it, travel through it as the fur traders did three centuries ago . . . To others, the local area residents who have no less an appreciation for those values, it is either their most accessible recreational area--and to most of them for only very limited day use--or the source of their livelihood, whether canoe outfitting, resort managing or timber harvesting. They never considered the BWCA a classic pure wilderness; rather a combination of primitive and multiple use."

OUTLINE HISTORY OF LEGISLATION AND LAND USE IN THE BWCA

Adapted from Outline History of the BWCA. M. L. Heinselman and H. C. Johnson. Friends of the Boundary Waters Wilderness, Duluth and St. Paul, MN.

1890- Logging of big pines in the future BWCA begins.
1926- Secretary of Agriculture Jardine issues proclamation establishing 1000 square miles of wilderness area in the Superior National Forest (SNF). Logging is allowed but no additional roads are to be built.
1930- Congress passes Shipstead-Nolan Bill, which prohibits logging within 400 feet of waterways, forbids building dams, and withdraws all public land in the SNF from homesteading.
1930- Forest Service acquires tax delinquent land in wilderness.
1941 and builds many portages and foot trails in the SNF.
1938- Forest Service establishes Superior Roadless Primitive Area (SRPA) with boundaries similar to present BWCA.
1941- Pulpwood logging begins along southern perimeter of SRPA. "Fly-ins"
1948 start to be established in SRPA by resorts.
1948- Congress passes Thye-Blatnik Act. Act directs Secretary of Agriculture to acquire resorts, cabins, and private holding within 2/3 of future BWCA . . . extended in 1956 to cover almost all of present BWCA.
1949- President Truman issues executive order forbidding flights below 400 feet over SRPA.
1958- Forest Service changes name of Superior Roadless Primitive Area to Boundary Waters Canoe Area.
1960- Congress passes Multiple Use-Sustained Yield Act which establishes multiple use concept in national forests and directs Secretary of Agriculture to promote logging up to level of sustained yield.
1964- Congress passes Wilderness Act. Exemption, applying only to BWCA, provides for continued timber harvesting and motor boat use.
1965- Secretary of Agriculture Freeman issues 13 directives on BWCA use from Selke Committee recommendations. Designates 19 routes for use by motor boats and snowmobiles and divides BWCA into 600,000 acre interior zone closed to logging and 400,000 acre portal zone open to logging.
1966- Copper-nickel prospecting increases outside BWCA.
1968- International Nickel Company (INCO) develops exploratory mine south of Ely.
1973- Federal District Court (Judge Neville) prohibits mining in BWCA.
1974- Decision prohibiting mining is appealed and reversed.
1975- Federal District Court (Judge Lord) bans logging of virgin timber. Congressman Oberstar introduces BWCA bill that would establish 400,000 acre National Recreation Area.
1976- 8th District Court of Appeals reverses Lord decision, thus permitting virgin timber logging. Congressman Fraser introduces bill to give BWCA full wilderness status. Secretary of Agriculture Butz bans snowmobiling and sets some size restrictions on motorboat use.

THE WILDERNESS ACT

Passage of the Wilderness Act in 1964, particularly the paragraph exempting the BWCA from certain provisions, has been a continuing source of controversy as to what land uses should be allowed.

The Act defines a wilderness as an area where "the earth and its community of life

are untrammeled by man, where man himself is a visitor who does not remain . . . retaining its primeval character . . . managed to preserve its natural conditions . . . where the imprint of man's work is substantially unnoticeable."

But the Act also provides that the BWCA be managed "in accordance with general purpose of maintaining, without unnecessary restrictions on other uses, including that of timber, the primitive character of the area . . . Provided that nothing in this Act shall preclude the continuance within the area of any already established use of motorboats."

The main areas of debate regarding land use in the BWCA have been mineral exploration and mining, logging and road building, and recreational use of motorboats and snowmobiles. At present mineral exploration and mining are banned on state lands within the BWCA and no mining is being done. Logging is currently allowed in the portal zone, but companies with timber leases have agreed to temporarily refrain from cutting in hopes of a legislative settlement. Motorized canoes and boats are allowed in designated areas comprising approximately 60 percent of the water surface, but snowmobiles are banned in almost the entire area.

PROPOSED BWCA LEGISLATION

Much of the current BWCA controversy is focused on two Congressional bills, one proposed by James Oberstar and one by Donald Fraser. At the time of this writing (April 1978), the House Subcommittee on National Parks and Insular Affairs has just completed consideration of the two bills and has proposed a compromise, the Burton-Vento Bill, which will be considered next by the House Interior Committee.

Since the original bills are representative of two basic points of view concerning the BWCA, those two bills, as well as the compromise bill, will be outlined briefly.

OBERSTAR BILL

1. Approximately 150,000 acres are added to the current BWCA.
2. The area is divided into two zones: the Boundary Waters Wilderness (715,000 acres) and the National Recreation Area (340,000 acres).
3. Within the Wilderness Area, timber harvesting, motor boating, and snowmobiling are prohibited.
4. The National Recreation Area is zoned to allow travel by motor boats of limited horse power (10 hp on smaller lakes, 25 hp. on 17 bigger lakes) snowmobiling on designated routes and logging of second-growth timber.
5. Mineral exploration and mining and logging of virgin timber is prohibited in both the Wilderness and National Recreation Area.

FRASER BILL

1. The BWCA is renamed the Boundary Waters Wilderness Area.
2. The following activities are prohibited in the entire Wilderness Area:
   a. Commerical timber harvesting and administrative cutting of timber to manipulate vegetation.
   b. Recreational use of motorized watercraft and snowmobiles, except for a 5-year phase-out period in hardship cases.
   c. Mineral exploration and mining.
3. Approximately 35,000 acres are added to the BWCA. These are areas that have been managed primarily as wilderness in the past.
4. Revisions proposed later by Fraser would provide funds or extend authority for the following features in order to deal with concerns about the economic impact of the legislation:
   a. In areas within the Superior National Forest but outside the BWCA: complete 110 miles of unfinished snowmobile trails; upgrade lake access and build campsites in areas well-suited to motor recreation; intensify forest management.
   b. Build more hiking trails inside the BWCA.
   c. Examine available alternative timber sales for the four timber companies now holding cutting rights in the BWCA.
   d. Allow resort owners on peripheral lakes to voluntarily sell their holdings to the government.
   e. Consider extending to 10 or 15 years the motor phase-out period for certain peripheral lakes and keeping others permanently open to motors.

BURTON-VENTO BILL

Provisions are essentially those of the Fraser Bill, including the recommended additions, with the following changes:

1. A 227,000 acre National Recreation Area is established outside the present BWCA to include the Echo Trail, Fernberg Road, and Gunflint Trail road corridors. State and local governments are to develop land use regulations within a model zoning code provided by the Secretary of Agriculture.

2. Motorboats of 10 hp. or less are permitted permanently on 12 peripheral Wilderness lakes and for 5 years during restricted seasons on 2 more.
3. Snowmobiling is permitted on 2 winter portages to allow access to Canada.
4. Mining and mineral exploration are prohibited within the Wilderness and National Recreation Areas.

MOTORIZED RECREATIONAL VEHICLES IN THE BWCA: PRO AND CON

The following are excerpts from various sources that either support or oppose the use of motorized vehicles in the BWCA.

TRENDS IN VISITOR USE

The trend is toward more canoe-paddling canoeists. They represent a greater proportion of total use, travel greater distances to get to the area, penetrate deeper into the BWCA, and stay longer than other types of users. In the early to mid 1960s visitors traveling by canoe (paddle and motor) barely outnumbered motorboats. Today, almost 70 percent of the visitors go by canoe. Between 1969 and 1977, the number of paddle canoe groups increased 90 percent while the number of motor canoe and motor boat groups increased only 15 percent. (From When the Wilderness Gets Crowded . . . ? David W. Lime, U. S. Forest Service, North Central Forest Experiment Station, St. Paul. Naturalist, Winter 1977.)

PADDLE CANOE vs. MOTOR CANOES AND BOATS: CONFLICT OR COMPATIBILITY IN THE WILDERNESS?

Motor canoes constitute only 10 percent of the total use but are a valuable means of distributing canoeists. Motors are used almost entirely by fishermen and the figures show their main use is in the spring and fall which does not conflict with the principal July-August paddle canoe use.

Nearly all motorboat use is by non-campers on perimeter lakes. These are almost entirely fishermen and their families who have accommodations at resorts, motels or homes outside the wilderness and use their boats to travel a few miles inside the BWCA for a day's angling, leaving at night. From the ecology standpoint, this use is the most compatible in wilderness preservation since these people do not camp and have no impact other than travelling on the surface of a few perimeter lakes . . . Rather than dismember this unique wilderness, motorized traffic helps to preserve its wild character by dispersing the heavy traffic on the major access routes. Motors help speed canoeists to the seldom used, more remote areas of the region. Wise, limited motor use will preserve and conserve the BWCA by scattering the influx of visitors over a larger area. (From Minnesota's BWCA--Multiple Use.. or Single Use? Boundary Waters Resource Committee, Ely, Minnesota.)

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Another important influence on experiences is the conflict that exists between non-motorized and motorized parties. Motors are permitted on 19 designated routes in the BWCA, or on about 60 percent of the total water acreage. As previous BWCA research uncovered, we found continued dissatisfaction on the part of paddlers with meeting motorized parties. The conflict is generally one-sided and appears to be much more severe than previous research has shown. Nearly half of the motorboaters said it wouldn't matter how many other parties they met per day. Significantly fewer motor canoeists (29 percent) and paddle canoeists (13 percent) felt that way. Paddle canoeists had the lowest threshold of sensitivity toward encounters with motorized parties. For example 93 percent of the paddle canoe parties preferred not to meet any motorboats per day; 83 percent of them preferred not to meet any motor canoes; but, only 10 percent of the paddling groups preferred to meet no other paddle canoes. (From When the Wilderness Gets Crowded . . . ? David W. Lime, U.S. Forest Service, North Central Forest Experiment Station, St. Paul. Naturalist, Winter, 1977)

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Canoeists' attitudes indicate that motorboating is incompatible with canoeing in a wilderness, and without priority the opportunity to choose wilderness canoeing would be reduced or lost. One motorboat seems to equal at least three canoes, from the canoeist's point of view, partly because boats destroy their wilderness and partly because motorboats will be observed by far more groups than will canoes, because they travel farther and make more noise. Simply dispersing all use to reduce local crowding without separating the two incompatible types would appear to be a mistake; instead of solving the problem it makes it more widespread. (From The Recreational Capacity of the Quetico-Superior Area. Robert C. Lucas, Lake States Forest Experiment Station, St. Paul. U. S. Forest Service Research Paper LS-15, 1964.)

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For people who wish to use motorboats, there are dozens of large and beautiful lakes open to motors immediately outside the BWCA . . . Similarly, snowmobiles can legally travel on national and state forest lands, on literally thousands of state lakes, in many state parks, and on thousands of miles of private and state trails. In contrast, those who seek a primitive canoe experience have no other option--this kind of wilderness canoe trip is not available anywhere else in the United States. (From Statement before Subcommittee on National Parks and Insular Affairs, Donald Fraser, August 4, 1977.)

SNOWMOBILES IN THE BWCA: PRO AND CON

PRO

1. A snowmobile ban keeps many lakes out of reach of day-use fishermen.
2. Snowmobiles pack cross-country ski trails, making it easier for the novice and moderately-accomplished skier to enjoy the area.
3. Snowmobiles are an important asset in rescue operations for lost or injured skiers.
4. Snowmobilers are major users of the area; it makes little sense to shut off this use when it conflicts with only a very small number of non-mechanized users.
5. Snowmobiles do not have a harmful effect on the physical environment because they run almost exclusively on lake surfaces and do not usually involve camping.
6. A ban violates snowmobilers' basic rights.

CON

1. The BWCA lake trout fishery is already seriously over-fished and cannot withstand any additional winter pressure.
2. Snowmobiles do pack trails, but their surfaces often interfere with ski travel. Wilderness travellers prefer to break their own trails and find snowmobile encounters unacceptable.
3. The use of snowmobiles for rescue work would not be prohibited by new legislation.
4. There is significant non-mechanized winter use and this use is growing.
5. The evidence on the effect of snowmobiles on the environment is inconclusive; they do interfere with the nesting of eagles in late February and March.
6. There are more than 6,000 miles of snowmobile trails outside the BWCA in Minnesota, while the BWCA is the only significant winter wilderness in the Midwest.

(From BWCA Winter Recreation Fact Sheet. Friends of the BWCA, Duluth and St. Paul, Minnesota. A review of selected research on the ecological impact of snowmobiles is presented in the November 1975 issue of Managing Minnesota's Environment, Number 8.)

ECONOMIC IMPACT OF PROHIBITING MOTOR VEHICLES IN THE BWCA

Approximately 50 resorts are located near the periphery of the BWCA. About 18 of these would be seriously affected by my bill; they are located on key motorboat routes leading into the BWCA and cater heavily to fishermen using motors. Located on Saganaga, Sea Gull, Clearwater, East Bearskin, Brule, Snowbank, Lake One, Fall, and Moose Lake and the Range River, these resorts could not send their motor clientele to alternative fishing spots were their lakes closed to motors. We hope they would be able to attract a different clientele, one more interested in wilderness-type experiences. Additionally, a few might be able to change over to canoe outfitting (some already base part of their business in outfitting), but outfitting is extremely competitive and a shift would, for most, require very difficult psychological and investment adaptations.

The field hearings underscored the need to make some provision for the most seriously affected resorts. We cannot and should not expect the local businessman to bear the full economic responsibility for whatever actions Congress might take. We must be sure that the resort owners are treated fairly. (Ed. note: See proposed additions to Fraser Bill, page 4.)

It should be remembered that only a very few resorts have the potential for being seriously affected. The majority of resort owners in the area fall either into a low impact category (approximately 15 resorts have available to them extensive fishing areas or water recreation areas outside the BWCA or are not physically located on lakes that would be closed to motors) or into a medium impact category (approximately 13 resorts base a significant portion of their business on BWCA fishing, but could send their clientele to large alternative areas of good fishing waters outside the BWCA and tributary to the resort lakes). In addition there are approximately 25 firms in the immediate vicinity of the BWCA that are engaged primarily in canoe outfitting; they would be likely to benefit directly from our bill. (From Congressional Record. Donald Fraser, August 4, 1977.)

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. . . . .Today, if the Fraser Bill passes, approximately 30 more Resorts/Canoe Outfitters and BWCA businesses would be bankrupted. In a survey of only eight of those that would be directly affected, a total of 85 jobs would be discontinued . . . annual incomes totalling $618,000 would be lost. This does not include an annual payroll of $700,000 paid by just one local logger whose future is doomed without Portal Zone harvesting. Even if adequate compensation were made to those businesses most affected, the loss in tourist numbers alone--the thousands desiring multi-activity vacations--would put many of the local tourist-dependent merchants and serivces out of business . . . (From Minnesota's BWCA--Multiple Use . . . or Single Use? Boundary Waters Resource Committee, Ely, Minnesota.)

FOREST MANAGEMENT IN THE BWCA

FOREST ECOLOGY AND TIMBER MANAGEMENT

The great variety in types and ages of vegetational communities in the Boundary Waters is due to varying combinations of topography, soils, moisture conditions, microclimate and other ecological factors. But the great variable that traditionally has shaped the area has been fire.

In the natural history of this area, lightning fires were a common occurrence. When fuels were sufficiently dry and winds favorable, a fire would sweep large sections of forest until it burned out against a natural fire break or until the weather changed. In the areas of the great red and white pines, the fires would generally only remove the understory, without killing the mature trees themselves, thus enriching the soil and preparing the way for young trees. Other species, such as jack pine, are genetically prepared for the cataclysm of fire, and are well adapted for regeneration. It is estimated that in the past an average of about one percent of the Boundary Waters Canoe Area burned each year, although with wide variability, leading to a complete replacement cycle of about 100 years. In this way, a constantly dynamic diversity was maintained throughout the area.

Suppression of fire changed all that. In the absence of the normal fire cycle, shade-tolerant species, which normally were only transient within an area, became entrenched and forced out the normal species. Now, pine, aspen, and birch are being choked out by balsam fir, spruce, and northern white cedar. Diversity is being lost, with consequences not only for the tree species themselves, but also for the intricate communities of plants and animals that depend on varying mixes of trees.

This situation is serious, and the Forest Service basically has three options. First, it can simply let present trends continue, a policy that will result in severe forest degradation along the lines described above.

Second, it can substitute artificial management techniques for fire's natural role, which is what the Forest Service intends to do throughout the Interior Zone with the administrative cutting proposed in the 1973 management plan. The forest would be manipulated so as to clear out "undesirable" species and replicate, to the extent possible, natural conditions. The trouble with this approach, of course, is that it will fail. Logging and fire are two different phenomena, and resemble each other only to the extent that live trees are killed. Logging would tend to deplete nutrients rather than build them up, would have different and generally deleterious effects on native wildlife, would cause erosion and degradation of water quality, would ruin the area for significant ecological research, and would generally compound rather than cure the synthetic man-made situation caused by fire suppression. It would also violate the very concept of wilderness by introducing new massive artificial manipulations and intrusions of disruptive activities.

The third alternative is to reintroduce fire, the natural means of maintaining forest ecosystems. The BWCA, with its vast network of interconnecting lakes, streams, and wetlands, is ideally suited for a program of prescribed burning. When weather is favorable, a fire can be set to burn up against a natural fire break and the burn can then serve as a fire break for further fires upwind. Although such a program must be experimental in the early years, to guard against threats to public safety and outside property, preliminary work done in western wilderness areas indicates that no insurmountable problems are likely to arise.

Through the prompt adoption of a wise fire policy, the ecologically damaging management mistakes of the past can be rectified in the relatively near future. (From Cutting Up in The Boundary Waters. H. E. Wright, Jr., University of Minnesota Departments of Geology and Ecology, and Jonathan Ela, Sierra Club Bulletin, May, 1974.)

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An obvious conclusion is that the ecological succession of the forest of northeastern Minnesota is disturbance-oriented. Whether the disturbances are created by man, accidentally or in management, or whether they are natural, caused by fire, wind, insects, and disease, a hypothetical climax forest would rarely be achieved. Nevertheless, in wilderness or natural areas, the ideal management is seemingly to let nature take its course. If the reproductive capacity of the species were not influenced by the impact of civilization, nature could be effective. Permitting wildfires to burn or using prescribed fire in standing timber in northeastern Minnesota can aid in the perpetuation of the aspen-spruce-fir complex or the restoration of jack pine and black spruce.

Modern influences on succession, even in remote areas, tend to eliminate rather than perpetuate the longer lived red pine and white pine following natural disturbances. These species cannot be restored by natural means to the position they represented in the forests of the past . . . A choice must be made between (1) establishing, through man's efforts, forests resembling the primeval stand or (2) by natural means, permitting the development of a forest in which other species predominate. It is possible to opt for each of these choices in different parts of the area. (From Regeneration of Red Pine and White Pine Following Wildfire and Logging in Northeastern Minnesota. Clifford E. Ahlgren, Wilderness Research Foundation, Duluth, MN. J. of Forestry. March, 1976.)

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Those who promote fire as the only management tool for use in wilderness and other recreation areas need to be concerned regarding the possible creation of holocaust fires that could cause loss of property and lives. Late summer or early autumn fires may be essential to accomplish desirable objectives. This is the period when practically all of the holocaustic fires of the Lake States have developed. This is the period of heavy canoeist use of the BWCA. Will they tolerate, understand and approve of such fire use and possible destruction? How much atmospheric pollution will be involved in such burning of the annual growth of the million acre BWCA or the 36 million acres of defacto wilderness areas of western national forest? The production of such great quantities of carbon dioxide and particulate matter that always accompanies forest burning operations may not be tolerable in the future. Who can say that 10 years hence there will not be drastic restrictions on, or complete elimination of, fire as a forest management tool, even for use with timber harvest.

In contrast to the use of fire, logging or timber harvest can be conducted in an almost infinite variety of ways and with a broad range of equipment.

Timber harvest is a process that can be and must be applied to recreation lands as well as to commercial forest lands. Without this management tool, the managers of forested parks, wilderness and other recreational areas have but one tool in their kit: prescribed fire---with all of its recognized limitations and associated hazards---danger of developing to catastrophic proportions, atmospheric pollution, etc. (From Timber Harvest: Renewer or Destroyer. Frank Kaufert, Dean Emeritus, College of Forestry, University of Minnesota. Timber Producers Bulletin, Dec.-Jan., 1973.)

The U. S. Forest Service, as an aid to planning, in 1972 placed the soils of the BWCA into categories based on productivity and sensitivity to disturbance. These two attributes could then be combined into a composite land capability index, defined as "an area's ability to support life (biological productivity) and its ability to sustain, or heal itself from, externally-imposed disturbances."

In the productivity rating, which attempted to evaluate such properties as fertility, water-holding capacity, and depth to an impervious layer, about 90 percent of the soils of the BWCA fell in the low productivity class while the remaining 10 percent fell in the moderate class. In the disturbance rating, which considers erodibility, stability, and compactibility, 90 percent of the soils were judged to have a high sensitivity to disturbance, 7 percent a moderately high sensitivity, and only 3 percent a moderate sensitivity to disturbance.

The composite land capability index, described above, therefore placed 90 percent of the soils of the BWCA in the low productivity class and the other 10 percent in the moderate capability class.

Based on this information, I believe that the soils of the BWCA are not well suited for sustained timber production in comparison to other soils in northern Minnesota. Wise land use suggests that intensive timber management activities should be limited to those better suited areas, while the BWCA should best be used for other purposes. (From Statement at hearings before the House Subcommittee on National Parks and Insular Affairs. D. F. Griegal, Departments of Soil Science and Forest Resources, University of Minnesota, July 8, 1977, Ely, MN.)

ECONOMIC IMPACT OF PROHIBITING TIMBER HARVEST

How is the wood use industry affected by the BWCA controversy? The Portal Zone of the BWCA has been a significant source of softwood timber (primarily jackpine and spruce pulpwood) since the early 1940's. From 8 percent to 12 percent of the annual requirements of industry of these species came from the BWCA. Timber cut in the BWCA was primarily over-mature, old-growth, and decadent stands. And, if not cut within the next 25 years or so, much of that which remains will be lost through insects, disease, and fire. Current U.S. Forest Service estimates for this annual loss total 40,000 cords for softwoods alone. At a time when using resources wisely is much on people's minds, this waste would be repugnant to everyone.

But why can't industry get replacement wood for the BWCA timber outside the BWCA?

The answer is that there is no extra annual allowable cut available outside the BWCA.

Federal, state and county timber in the 18 northeastern Minnesota counties furnish the bulk of industry's wood needs. These agencies are cutting their full annual allowable cut of softwoods at this time.

And, predictions of wood requirements and availability by the year 2000 show that we need all the commercial forestland base we now have. (From Forestry Requires First Of All, Trees. M. J. Latimer, Blandin Paper Company. Timber Producers Bulletin, Oct.-Nov., 1977.)

If logging of the entire Portal Zone were permitted, the Forest Service estimates the annual allowable cut of softwoods at 45,000 cords or 5 percent of Minnesota's softwood cut. But the last statewide forest survey shows a 274,000 cord annual surplus of balsam outside the BWCA, plus smaller surpluses of pine and spruce. Huge areas of aspen, birch, and other hardwoods are also under-harvested, and the annual surplus of these species outside the BWCA is more than a million cords--half the present statewide timber cut.

These timber surpluses mean that small changes in the species mix at the paper mills could easily cover any shortages of pine or spruce.

By arguing for BWCA softwoods, the timber companies are really making a case for cutting the last virgin forests in the Portal Zone, because most good pine and spruce forests in the BWCA are in areas that have never been logged. But these virgin areas are protected by both the Oberstar and Fraser bills so the real discussion in Congress centers on the previously-logged areas within Rep. Oberstar's proposed National Recreation Area. Much of that area has been logged since World War II and will not contain merchantable timber for another 20 to 50 years. The mature softwoods within the proposed NRA are mostly mixed with aspen and birch, and Minnesota has millions of acres of similar forests outside the BWCA. The allowable annual cut of softwoods from the proposed NRA is only 21,000 cords, a mere one percent of Minnesota's statewide cut.

The best way to provide for any needed extra softwoods in the next 10 to 20 years is by accelerating good forestry on better lands outside the BWCA and closer to the pulpmills. Minnesota has 16 million acres of productive forest land outside the BWCA and other reserves. With good forestry, we can grow all our timber needs on half that area. (From Memo on the BWCA Logging Issue. M. L. Heinselman, retired from the U.S. Forest Service. Friends of the Boundary Waters Wilderness, Jan., 1978.)

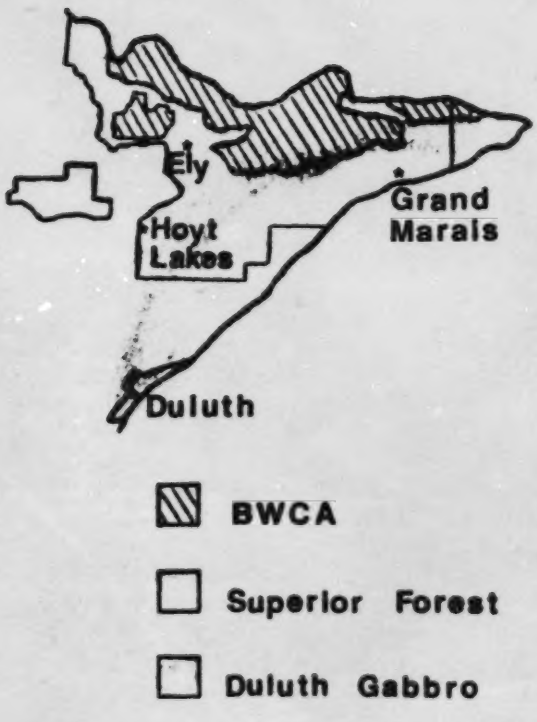
COPPER-NICKEL MINING IN MINNESOTA

by William Jokela, University of Minnesota

Although there has been no mining within the BWCA and there is no immediate threat to do so, exploratory work has been and is currently being conducted in the immediate area of the Boundary Waters. It is concern about those operations and the potential for full-scale mining development that makes copper-nickel mining a current issue.

LOCATION AND EXTENT OF COPPER-NICKEL DEPOSITS

Exploration for copper and nickel in northeastern Minnesota has centered on the rocks of the Duluth Gabbro Complex, a large body of basic igneous rocks. Deposits of possible commercial value are associated with certain phases of the gabbro which are concentrated as small bodies along the northern and western edge of the Gabbro Complex (see map). Most of the area favorable for prospecting (probably about 80 percent is outside the BWCA). Exploration has indicated that even along this favorable basal contact area only about 2 percent has possible commercial potential.



Content of copper and nickel in the mineable rock of the Gabbro Complex is quite low, about .5-.8 percent. But the 6.5 billion tons of mineralized rock (Minnesota Geological Survey estimate) contain an estimated 94 percent of the identified resources of nickel in the U.S. and 10 to 40 percent of the identified resources of copper.

PAST AND CURRENT MINING ACTIVITY

Copper and nickel-bearing rock was discovered in 1948 during construction of a logging road near the South Kawishiwi River southeast of Ely. Exploration has taken place, though somewhat sporadically, since that time. Since the state's long-term leasing arrangements were established in 1966, several companies have signed mining leases for extensive acreages of state and federal lands outside the BWCA.

In 1969 George St. Clair, a private prospector, attempted to drill on land within the BWCA to which he owned mineral rights. He was stopped by the Forest Service and in 1973 a permanent injunction was issued prohibiting mining in the BWCA. However, the decision was appealed and reversed and gave the Forest Service the authority to grant or refuse permits for mining operations. In 1976, Minnesota legislation banned mining on state lands within the BWCA.

Recent mining exploration has centered on 2 areas located just outside the BWCA. International Nickel Company (INCO) has done extensive exploration and bulk sampling at a site southeast of Ely and submitted a proposal for an open pit mine next to the South Kawishiwi River about a mile from the BWCA. The mining operation, including the open pit mine, wasterock pile, lean ore pile, and tailings basin would cover about 5,000 acres. The Forest Service encountered problems with the company in developing an Environmental Impact Study and in 1975 INCO withdrew its request for the proposed mine, reportedly to await a clarified state mining policy and a more favorable metals market.

A second exploration site is the MINNAMAX Project located just outside Babbit about 20 miles south of the BWCA. AMAX Company is currently sinking a 14-foot diameter shaft 1700 feet deep to determine the extent and quality of mineralization. Any eventual mining at the site would be done by underground methods. AMAX has been conducting extensive water quality and other environmental monitoring in cooperation with governmental agencies.

ENVIRONMENTAL CONCERNS

Mining of the copper-nickel sulfite ore in northeastern Minnesota requires a series of operations--exploratory drilling, excavation, and construction of mining facilities, stockpiling of waste and lean ore, construction of a water reservoir, and several processes to concentrate the low grade rock.

Potential sources of polluted waters from a mining operation include contamination of water used in processing, escape of water from tailings disposal sites, and contaminated runoff or seepage from waste rock dumps or lean ore piles. The volume of water removed from the surface of ground waters of the watershed would depend on the number and size of operations and the technology used. But withdrawal of significant volumes of water could potentially affect water levels and concentration of pollutants.

Disposal of solid wastes poses a problem. In underground mining a large portion of the waste can be redeposited underground, but in open pit mining all tailings must be deposited on the surface in addition to overburden, wasterock, and lean ore. Dust from blasting, crushing, and hauling operations and from unstabilized tailings sites can cause air pollution.

If copper-nickel mining is undertaken near the BWCA, a smelting plant may or may not be built in the immediate vicinity. Such plans have been proposed in the past. Wherever a smelter is located, it poses the following problems: emission of sulphur dioxide gas, causing injury or death to intolerant species such as white pine and lichens, acidification of rain with subsequent damage to ecosystems downwind, and heavy metal contamination of downwind soils and downstream waters. In recent years advances have been made in anti-pollution technology of smelters so it is difficult to predict the level of pollution to be expected from these sources.

A Regional Copper-Nickel Study, initiated and organized by the Minnesota Environmental Quality Board, is currently being conducted in northeastern Minnesota. The objectives of the study are to characterize the region as it

presently exists, in the absence of mining development, and to assess the potential impact, environmental, social, and economic, of various levels of copper-nickel development. Results of the study are to be used by the legislature and other state agencies to develop a comprehensive policy for mining development in the area. Completion of the study is expected by early 1979.

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Malcolm, J. B. The MINNAMAX Exploration Project.

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BIBLIOGRAPHY

The Environmental Conservation Library (ECOL) in Minneapolis has a large collection of books, studies, research reports, environmental impact assessments, pamphlets, Federal court decisions, and periodicals relating to the Boundary Waters Canoe Area. The list is too long to include in this newsletter. Persons interested in the ECOL bibliography on the BWCA should request a copy of ECOL NEWS, Vol. 3, No. 4, February, 1976, from Environmental Conservation Library, 300 Nicollet Mall, Minneapolis, MN 55401.

ECOL now has the following items which are not listed in the 1976 bibliography.

"Confusion at Boundary Waters Canoe Area" by Dean Rebuffoni in National Parks and Conservation Magazine, January 1977, p. 12.

"Crisis in the canoe country" by Miron L. Heinselman in The Living Wilderness, Jan./Mar. 1977, p. 14.

"In canoe country" by H. E. Wright, Jr., in Not Man Apart, May 1977, p. 1.

"North country forests gets six-month reprieve" in National Parks & Conservation Magazine, March 1977, p. 26.

"Outdoor America update: Boundary Waters Canoe Area" in Outdoor America, June-July 1977, p. 18.

"Passionate suitors for a wild paradise" by William O. Johnson, in Sports Illustrated, Oct. 10, 1977, p. 50.

"We like it wild" in National Parks & Conservation Magazine, Oct. 1977, p. 20.

"When the wilderness gets crowded . . . ?" by David W. Lime in Naturalist, Winter 1977, V. 28, No. 4, p. 1.

Continuing coverage of federal legislation can be found in issues of Conservation Report (National Wildlife Federation), Sierra Club National News Report, and Wilderness Report (Wilderness Society).

Some other organizations which can supply information on BWCA issues:

Boundary Waters Conservation Alliance
22 Phoenix Building
Duluth, Minnesota 55802
Phone (218) 727-2935

Minnesota Forest Industries Information Committee
200 Christie Building
Duluth, Minnesota 55802
Phone (218) 722-5013

Friends of the Boundary Waters Wilderness
P.O. Box 98
Anoka, MN 55303
(612) 427-1800

P.O. Box 55
Duluth, MN 55801
(218) 525-5018

BWCA SLIDE SHOW/TALK
The Minnesota Forest Industries Information Committee has a BWCA slide/talk show. A representative of the organization is available to present the show or they can lend the slide/tape set (20 minutes of tape). For more information contact the Minnesota Forest Industries Information Committee, 200 Christie Building, Duluth, MN 55802. Phone (218) 722-5013.

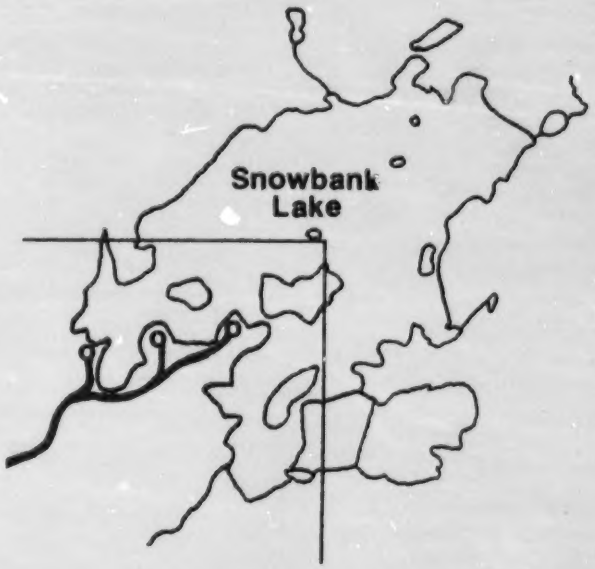
STUDENT MATERIALS

TASK A: BACKGROUND INFORMATION Individual Activity

TASK

Read the following information on the Boundary Waters Canoe Area. A bill is being drafted in Congress to determine whether the BWCA will be (1) a wilderness region only or (2) open for both recreation and wilderness (called multiple use). Your Senator is seeking input from local interest groups to determine how the area should be used. Below is some important information about the BWCA that you will need. Underline the parts that you think are most important.

THE BOUNDARY WATERS CANOE AREA



The Boundary Waters Canoe Area, located in northeastern Minnesota, is the largest National Wilderness Area east of the Rocky Mountains--slightly over 1 million acres in size. As a vast area of interconnecting waterways, amidst virgin conifer forests, it is our only lakeland wilderness and unique in the National Wilderness System. It stretches for more than 100 miles along the Minnesota-Ontario border and supports unique northern fish and wildlife populations. Together with its sister area the million acre Quetico Provincial Park in Ontario, where all logging and most motorized recreational uses are already prohibited, these two areas comprise one of the finest wilderness regions on the continent.

--Friends of the Boundary Waters Wilderness

Snowbank Lake lies on the southern boundary of the wilderness area. For this reason, the northern portion of the lake lies within the Boundary Waters Canoe Area and the southern portion of the lake does not lie within the wilderness area. There are three large resorts on this southern shore. Resorts in the canoe area are not allowed.

The north and west sides of the lake contain large areas of valuable timber. Since these areas are within the wilderness area, cutting of the timber is strictly regulated.

The western side of the lake lies along the Duluth Gabbro rock formation which stretches from Duluth in the south to north of Grand Marais. Mining south of the Boundary Waters Canoe Area has shown this rock formation to be rich in copper and nickel deposits.

TASK B: ANALYSIS

Individual or Small Group Activity

TASK

Read the information sheets on THE WILDERNESS ACT and on MULTIPLE USE. Your task is to think of as many advantages and disadvantages of making the Boundary Waters Canoe Area a wilderness area or a multiple use area.

WILDERNESS	MULTIPLE USE
ADVANTAGES	ADVANTAGES
TO PEOPLE	TO PEOPLE
TO NATURE	TO NATURE
DISADVANTAGES	DISADVANTAGES
TO PEOPLE	TO PEOPLE
TO NATURE	TO NATURE

THE WILDERNESS ACT

The Wilderness Act defines a wilderness as an area: "Where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain, retaining its primeval character, managed to preserve its natural conditions -- where the imprint of man's work is substantially unnoticeable."

The main purpose of the Wilderness Act is to set aside large areas of land to remain as natural as possible. This limits activities of human within the Wilderness Area so that they don't change the natural state of the region.

Specifically, the following activities are prohibited within a Wilderness Area:

1. Commercial timber harvesting and administrative cutting of timber to manipulate vegetation;

2. Recreational use of motorboats and snowmobiles; and

3. Mineral exploration and mining.

NOTE: Certain exceptions have been made in this act as it applies to the Boundary Waters Canoe Area. These exceptions are at the center of the controversy regarding the area. On many BWCA lakes, motorboating is allowed, but with motors of limited size (usually 10 hp on small lakes and 25 hp on some larger lakes). Also lumbering is allowed in specific regions for forest management. Mining and snowmobiling are not allowed at this time.

MULTIPLE USE

Multiple Use is based upon a congressional bill proposed by Congressman James Oberstar. In this bill, tbe BWCA would be divided into two areas, the Boundary Waters Wilderness and the National Recreational Area.

Within the Wilderness Area, timber harvesting, motor boating, and snowmobiling would be prohibited. Also prohibited would be mineral exploration and mining.

The National Recreational Area would allow boats of limited size (10 to 25 hp), snowmobiling on specially designated routes, and limited logging.

The Boundary Waters Wilderness Area would make up about 2/3rds of the present wilderness area and the National Recreational Area would make up about 1/3rd of the present wilderness area.

TASK C: STRATEGY SESSION — Small Group Activity

TASK

(1). Meet with your assigned group.
(2). Carefully read your group assignment.
(3). Answer the following questions.

1. What is our position on the issue of use of the BWCA?

2. What support do we have from the Wilderness Act or from the Multiple Use Bill?

3. What questions do we still have?

4. What additional information do we need?

TASK

After you have filled out these two parts, you may look at the DATA SHEETS. These give some additional information which might be useful in preparing your recommendations. After you have read the DATA SHEETS, make a list of some of the recommendations that you would make to the committee.

RECOMMENDATIONS

TASK C - PAGE 2: STRATEGY SESSION, cont.

TASK

Look at your list of recommendations and think about what effect each recommendation would have ON PEOPLE and ON NATURE. When you do this you are making an ENVIRONMENTAL IMPACT STATEMENT. This is a careful study of the effects of a bill on the environment and is very important to the senate advisory committee.

RECOMMENDATION	EFFECT ON PEOPLE	EFFECT ON NATURE

TASK

Develop your final presentation. You must follow these rules.

(1). The presentation cannot be longer than five minutes.

(2). You must have a visual display such as a land use map drawing as a part of your presentation.

(3). More than one person in your group must help in the presentation.

Think carefully about how you want to present the information. It might be helpful for you to outline your presentation below. Finally, PRACTICE YOUR PRESENTATION.

YOUR RECOMMENDATIONS

TASK C -- PART 2: SENATE ADVISORY COMMITTEE Small Group Activity

TASK

You represent the decision-making body which will present a report to the United States Senate upon which legislation will be drafted to determine how the Boundary Waters Canoe Area will be used. In the next 20 minutes you are to:

(1). Elect a chairperson to call the groups and chair the board meetings.

(2). Determine a plan for evaluating each presentation and the points that they make. You may wish to use the following form. What points will you look for? What sort of evidence will you need to make a decision? As an example, you might ask if the groups considered the effects of their recommendations on people and on nature.

SOME POINTS TO LOOK FOR

TASK

(3). Decide upon some method for keeping track of the information that is presented to you and the points that each group make. You might like to use the following form.

PRESENTATION	GOOD POINTS

DEBRIEFING: THINKING ABOUT YOUR GROUP ACTIVITIES

Individual and Large Group Activity

TASK

You have just finished working with several other people on a presentation to a senate advisory committee. Think about your activities for the last several days and then answer the questions listed below.

1. Did your group work as a team? _____

2. Did some people dominate the discussion? ____ Why or why not? _____

_____

3. Did your group take the activity seriously? _____

Why or why not? _____

_____

4. What did you learn from this activity? _____

_____

_____

Thinking about the Boundary Waters Canoe Area Case Study

1. What additional data would you have liked to have had for your group? _____

_____

_____

2. How do you feel about the decision made by the Senate Advisory Committee? Do you feel that they were fair? _____

_____

_____

GROUP ASSIGNMENTS AND DATA SHEETS

GROUP ASSIGNMENT--RESORT OWNER

NAME: Richard and Marion Johnson
AGE: 43 and 45
OCCUPATION: Resort Owner--The Snowbank Lodge
MISCELLANEOUS: Three children, ages 25, 23, and 20. The oldest two children help run the lodge.

You are the owner of the Snowbank Lodge, a resort on the south shore of Snowbank Lake. This resort was first started by your parents in 1935 and was passed on to you in 1960 when your parents retired to Florida. Both you and your wife have run the resort since then. For the past 5 years, your two oldest sons have also helped to run the resort, and you hope to turn the resort over to them when you retire.

The resort is composed of a large central lodge with dining areas, a general store, and an outfitting shop which provides camping, fishing and canoeing equipment for people wishing to use the Boundary Waters Canoe Area. You are one of the major outfitters for canoe trips in the area and about 50% of your business comes from this source.

There are also 12 cabins on the property and your family home. The cabins generally provide week-long lodging during the summer and weekend lodging during the winter. They each have two bedrooms and a small kitchen. About 50% of your business comes from renting these cabins.

You are interested in seeing the recreational uses of the region expanded (motorboating, snowmobiling, camping), since that would mean more business for you. You would not like to see the area declared a wilderness because it would severely cut down your business (especially during the winter) and might even put you out of business. You also would not like to see widespread mining and lumbering because that would destroy the natural beauty and the fishing that your tourists come to see.

GROUP ASSIGNMENT--MINER

NAME: George Abbott
AGE: 53
OCCUPATION: Miner for International Nickel Company (INCO)
MISCELLANEOUS: Married with 4 children ages 28, 25, 20, and 17.

You are a miner with the International Nickel Company and have been employed by them for 25 years. You supervise strip mining operations at the INCO mine just south of the boundary waters area.

The Northeastern Minnesota area has the potential for being one of the largest sources of nickel in the United States. Currently, the U.S. imports much of its nickel from Canada.

Mining is important to the economy of Northeastern Minnesota. Thirty-three percent of the people in this region receive their income from mining. Many of your friends as well as your own family depend on the mining industry for a living.

Recently mining in areas outside of the Boundary Waters Area has been declining because the cost is becoming too great to continue mining at the depths required. There are rumors that there will be widespread layoffs if something is not done.

During the last year, mineral exploration along the periphery of the Boundary Water Canoe Area have given indications that there may be major mineral deposits within the limits of the Boundary Waters Canoe Area.

You are anxious to see mineral exploration expanded to include the Boundary Water region since it would mean an expanded job market, as well as a large influx of money into the region. In addition, increased mining would reduce the U.S. dependence upon foreign sources of nickel.

GROUP ASSIGNMENT--TIMBER

NAME: John Carlson
AGE: 40
OCCUPATION: Owner of a small lumber company
MISCELLANEOUS: Married, two children ages 15 and 12.

You own a small lumbering company operating outside of the Boundary Waters Area. You are interested in expanding your operation to include the Boundary Waters Canoe Region around Snowbank Lake.

You have a college degree in forest management and are familiar with modern techniques of management. You realize that the Boundary Waters region has, throughout history, been maintained naturally by fire. This burned off the less desirable types of trees which would block the light from the more desirable types of trees. It is estimated that throughout history, about 1% of the boundary waters area was burned off each year.

Now that the fires are controlled, trees that grow better in shady areas such as balsam, fir, spruce, and white cedar are growing and choking out the trees that need more light such as pine, aspen, and birch.

Three options exist. First, nothing can be done and the shade tolerant trees can overtake the area. This is what would happen under the Wilderness Act. A second option would be to introduce controlled fires such as would have naturally taken place. The third option is the one that you would prefer. Under this option, lumbering would be allowed to clear out the undesirable species. This way the lumber would not be destroyed by fire, but would be available for the housing market, heating, etc.

GROUP ASSIGNMENT--RECREATIONAL USER

NAME: Bill and Mary Thompson
AGE: 35
OCCUPATION: Gas station owner, Minneapolis
MISCELLANEOUS: Three children, ages 17, 15 and 12.

You are a frequent user of the Boundary Waters region and the surrounding Superior National Forest. Each summer your family rents a cabin at the Snowbank Lodge for a week of canoeing and fishing in the Boundary Waters Area. You really enjoy the peace and quiet of the lakes, but you also enjoy the recreational opportunities that the area offers such as powerboating, water skiing, and snowmobiling, and you would like to see the BWCA area make provisions so that at least a portion of the area would be available for recreational use. You feel that if the recreational use of the area was expanded, then more people would use the Boundary Water Area. Being a business man, you recognize that this would bring a lot more money into the area.

You would support a program to open a portion of the BWCA (those lakes, such as Snowbank which are on the border, as well as a few larger lakes in the interior of the BWCA) to recreational use which would allow powerboats, snowmobiles, and perhaps even some lodges. The remainder of the BWCA would be reserved as a wilderness where motorized vehicles would not be allowed.

GROUP ASSIGNMENT--ENVIRONMENTAL GROUP

NAME: Susan Edwards
AGE: 28
OCCUPATION: President, Save The Wilderness League
MISCELLANEOUS: Married, two children ages 5 and 7

Your are the president of the Save the Wilderness League. This is an organization of individuals who are interested in seeing that the BWCA is preserved as a wilderness. You have members from all over the state, but chiefly your members tend to come either from the Twin Cities metropolitan area or from NE Minnesota. You have been very active lobbying with congressional leaders from the state as well as with the state senators.

Simply, you would like to see the BWCA region preserved as a wilderness area according to the Wilderness Act. You would prohibit motorboating and snowmobiling because of their damaging effects on the environment. You would also prohibit mining and lumbering because these activities, even when done with the best sort of management in mind, still alter the natural state of the land. You probably would like to prohibit any camping or boating in the region, but you realize that this is unrealistic. You do, however, propose severe limitations on the number of people who will be allowed in the area at any one time, and a limit on the length of time that they can remain in the region. In order to enter the BWCA you would need a permit from the State Department of Natural Resources.

You strongly oppose any attempt to designate any portion of the BWCA as a recreational area which would allow motorized boats or snowmobiles since this is the only lakeland wilderness.

Data Sheet

LUMBERING

Throughout history, forests have naturally been managed by lightning fires. It is estimated that 1% of the BWCA burned every year. Without some sort of burning, poorer quality trees which can grow in the shady, overcrowded forests tend to take over the better quality trees which need lots of light. There are three ways to handle this:

1. Do nothing. Let the natural process take over and let the shady trees overgrow the better quality trees, but not interfere with the natural process.

2. Controlled fires. Set fires in a controlled manner to burn off certain trees.

3. Controlled lumbering. The management of forests through the cutting of specific regions and the careful replanting of high quality trees.

While controlled lumbering is less wasteful than controlled fires, it also removes nutrients from the soil that would be returned to the soil by the burning or decay of the trees. Over a period of time this may remove so many nutrients from the soil that the soil will no longer be able to support the growth of trees.

From 8-12% of the state's annual softwood timber comes from the BWCA.

Much of the timber cut in the BWCA is primarily overmature, old growth, which, if not cut, would decay in 25 years or so or be lost through insects, disease and fire.

The U.S. Forest Service estimates an annual national loss totalling 40,000 cords for softwoods alone.

About 50% of the BWCA was logged before 1900.

Data Sheet

SCIENCE

The lakes in the BWCA were formed by the action of glaciers. The glaciers acted like giant scrubbing brushes and removed the topsoil, leaving a hard-rock lake bottom. This type of lake can easily be damaged by acid rain. In fact, the BWCA is considered one of the prime targets for acid rain damage. In the Adirondack Mountains of NY, nearly half of the lakes no longer have fish because of the acid in their water. Refining the metals releases gases into the air which combine with rain to form the acid.

There is no scientific evidence as to the environmental effects of snowmobiling. There is some feeling that the snowmobiles interfere with the nesting of eagles in February and March.

In order to maintain a healthy forest, some process must take place for thinning out the growth of trees. Most commonly, this has happened naturally through lightning fires, but with improved firefighting techniques, widespread fires are not as common. For this reason, if good quality trees are to survive in the BWCA it will be necessary to either allow the natural process of lightning to go on, to log the area, or to set controlled fires. Burning and natural decay of the timber returns the nutrients to the soil--lumbering does not.

Data Sheet

GEOGRAPHY AND FACILITIES

IN THE BWCA

Number of Lakes	1,060
Area of Lakes (Acres)	157,676
Area of Land	872,013

TOTAL PUBLIC LANDS IN STATE OF MINNESOTA

Federal Ownership	3,200,000
State Ownership	5,800,000
County Ownership	3,000,000

CAMPING FACILITIES

In the BWCA	2005 Campsites

Data Sheet

FEELINGS

In a survey of individuals using the BWCA, nearly half of the motorboaters said that it wouldn't matter to them how many other groups they met in a day. However, only thirteen percent of the canoeists felt that way. Ninety-three percent of the paddle canoeists preferred not to meet any motorized boats per day, but only 10% of the paddling group preferred to meet no other paddle canoes.

"We consider the BWCA to be a priceless national heritage for all to use and enjoy . . . for now as well as future generations. It can continue to be if competent and fair management policies are established and followed."
--Ely, MN Chamber of Commerce

"The wilderness, or what we call the wilderness, cannot be recreated. Once gone, it is gone for all time. It was an argument offered years ago in many parts of the country, and effectively ignored or evaded or arrogantly crushed until now there is only a frail remnant left. And there is no other place for the canoeist like the Boundary Waters of Northern Minnesota. They come by the battalions sometimes in the summer. But almost invariably they leave the canoe country better for the experience."
--Jim Klobuchar, March 27, 1978

Data Sheet

ECONOMICS

Percent of Payroll in Primary Industries

Mining	33%
Timber	2%
Lodging/outfitting	1%

(This represents the percent of the people in NE Minnesota who have jobs in these three areas.)

Comparison of Tourism in NE Minnesota with Motorized Use of BWCA

BWCA Motor use by Tourists	Total Tourism	Percent
65,000	2,500,000 (summer)	3%

Impact of Motor Restrictions on Resorts

Numbers of Lodging Est. in NE Minn

Motels/ Motels	Resorts	Affected by motor ban
106	297	47

Who Uses the BWCA (Figures from 1975)

Paddle canoes	22,227
Motors, canoes & fishing boats	15,417
Hiking	1,098
Skiing and snowshoeing	838
Snowmobiling	2,116

NOTE: snowmobiling was banned in winter of 1976-1977

Data Sheet

PRO AND CON: SNOWMOBILES

PRO:

1. A snowmobile ban keeps many lakes out of reach of day use fishermen.
2. Snowmobiles pack cross country ski trails, making it easier for the novice and moderately accomplished skier to enjoy the area.
3. Snowmobiles are an important asset to rescue operations for lost or injured skiers.
4. Snowmobilers are major users of the area; it makes little sense to shut off this use when it conflicts with only a very small number of non-mechanized users.
5. Snowmobiles do not have a harmful effect on the physical environment because they run almost exclusively on lake surfaces and do not usually involve camping.

CON:

1. The BWCA lake trout fishery is already seriously overfished and cannot withstand any additional winter pressure.
2. Snowmobiles do pack trails, but their surfaces often interfere with ski travel. Wilderness travellers prefer to break their own trails and find snowmobile encounters unacceptable.
3. The use of snowmobiles for rescue work would not be prohibited by new legislation.
4. There is significant non-mechanized winter use and this use is growing.
5. The evidence on the effect of snowmobiles on the environment is inconclusive; they do interfere with the nesting of eagles in late February and March.
6. There are more than 6,000 miles of snowmobile trails outside the BWCA in Minnesota, while the BWCA is the only significant winter wilderness in the Midwest.

STUDENT PRE/POST TEST

NAME _____ DATE _____

1. The size of the Boundary Waters Canoe Area is slightly over

   a. one half million acres
   b. one million acres
   c. three million acres
   d. ten million acres

2. The Quetico Provincial Park

   a. is in Ontario, Canada
   b. prohibits all logging and most motorized recreational use
   c. is one million acres in area
   d. all of the above

3. The Duluth Gabbro

   a. is a rock formation rich in nickel and copper
   b. is a region of the BWCA containing chiefly oak trees
   c. does not go through the BWCA
   d. is the oldest rock formation in Minnesota

4. The major purpose of the Wilderness Act is

   a. to reduce pollution across the nation
   b. to set aside natural areas to remain unchanged
   c. to provide reserves for dangerous wild animals
   d. to provide recreational areas for motorboating

5. The most important difference between the Wilderness Act and the Multiple Use Act is

   a. the regulation about hunting
   b. the regulation about fishing
   c. the regulation about motorboating and snowmobiling
   d. the regulation about how many people can use the area

6. The Multiple Use Act does not

   a. allow motorboating
   b. allow snowmobiling
   c. allow mining
   d. allow timber harvesting

7. Which of the following is a way of managing forests?

   a. fire
   b. pesticides
   c. strip mining
   d. all of the above

8. All of the following are advantages of allowing snowmobiling EXCEPT

   a. they pack cross country ski trails
   b. they aid in rescue operations
   c. they allow for winter fishing
   d. they bring people to the area during the winter off-season

9. Which of the following industries provides the highest percentage of the payroll in NE Minnesota?

   a. timber
   b. mining
   c. lodging
   d. outfitting

10. Which of the following is a disadvantage to nature of timber harvesting?

   a. undesirable shade resistant trees are removed
   b. roads are built to allow equipment to carry trees to market
   c. new trees are planted where old trees have been cut down
   d. all of the above

TEACHER ANSWER KEY

1. b
2. d
3. a
4. b
5. c
6. c
7. a
8. c
9. b
10. b

ACID PRECIPITATION CONTROVERSY

Schedule:

1. Meet with your partner and plan how to argue effectively for your position. Make sure you and your partner have mastered as much of the position as possible.

2. Each pair presents their position. Be forceful and persuasive in presenting your position. Take notes and clarify anything you do not understand when the opposing pair presents their position.

3. Open discussion. Argue forcefully and persuasively for your position, presenting as many facts as you can to support your point of view. Critically listen to the opposing pair's position, asking them for the facts that support their point of view. Remember, this is a complex issue and you need to know both sides to write a good report. Work together as a total group to get all the facts out. Make sure you understand the facts that support both points of view.

4. Role reversal. Reverse the perspectives in the group by each pair arguing the opposing pair's position. In arguing for the opposing pair's position, be as forceful and persuasive as you can. See if you can think of any new facts that the opposing pair did not think to present. Elaborate their position.

5. Come to a group decision that all four of you can agree with. Summarize the best arguments for both points of view. Detail what you know (facts) about Acid Precipitation and the Industrial and Environmental points of view. When you have consensus in your group, organize your arguments to present to the entire class. Other groups may make the opposite decision and you need to defend the validity of your decision in the entire class.

RULES:

1. I am critical of ideas, not people. I challenge and refute the ideas of the opposing pair, but I do not indicate taht I personally reject them.
2. I focus on coming to the best decision possible, not on "winning."
3. I encourage everyone to participate and to master all the relevant information.
4. I listen to everyone's ideas, even if I don't agree.
5. I restate what someone has said if it is not clear.
6. I first bring out all ideas and facts supporting both sides, and then I try to put them together in a way that makes sense.
7. I try to understand both sides of the issue.
8. I change my mind when the evidence clearly indicates that I should do so.

Acid Precipitation Controversy

Pro Environment

"A chemical leprosy is eating away at the face of the U.S. It's popularly known as acid rain, but rain isn't the only culprit. The true name for this phenomena is acid precipitation. In addition to acid rain, it includes acid snow, acid sleet, acid hail, acid frost, acid rime, acid fog, acid mist, acid dew and 'dry' deposits of acid particles, aerosols and gases. And it's not only this country's problem. It is, however, the responsibility of the U.S. - as both perpetrator and victim of this ecological crime - to recognize the extreme dangers of acid precipitation and to take steps to remedy it before it becomes o persasive as to be irreversible."

Your position is to take legislative action immediately to rectify the problem of acid precipitation. Whether or not you agree with this position, argue for it as strongly as you can. Use arguments that make sense and are rational. Be creative and invent new supporting arguments. Remember to learn the rationale for both your position and the industrial position. Challenge the industrial position; think of loopholes in their logic; demand facts and information to back up their arguments.

1. Acid precipitation can kill fish and other aquatic life outright. In Scandinavia, which is downwind of pollution pumped into the skies of Western Europe, it has already destroyed fish life in 5,000 lakes in Southwestern Sweden and in seven Atlantic salmon rivers and 1,500 lakes in southern Norway.

2. Acid precipitation can have damaging effects on human health through inhalation and leaching of toxic materials into drinking water supplies.

3. Acid precipitation may pose a menace to crops and forests.

4. Acid deposition is already disfiguring buildings and monuments, including the U.S. capitol. The east side of the capitol has craters ¼ inch or more in it. Because of acid precipitation, the hard minerals in the marble have changed to talc.

5. Although the data are meager, the evidence indicates that in the last 20 to 30 years, the acidity of the precipitation has increased in many parts of the U.S. At present the U.S. annually discharges more than 26 million tons of sulfur dioxide into the atmosphere. Just three states, Ohio, Indiana, and Illinois, are responsible for nearly a quarter of this total.

6. Acid precipitation occurs when sulfur dioxide and nitrogen oxides combine in the atmosphere and change chemically into acid, which falls to the earth mixed with some form of precipitation. The pollutants come primarily from burning coal and petroleum. About 90% of the sulfur in the atmosphere of the northeastern United States comes from man-made sources.

Acid Precipitation Controversy

Pro Environment

Page Two

7. Overall, two-thirds of the sulfur dioxide in the U.S. skies comes from gas-, coal-, and oil-fired power plants. Other sources: industrial boilers, smelters and refineries, 26%; commercial institutions and residences, 5%; and transportation, 3%. Between now and the year 2000, utilities are expected to double the amount of coal burned.

8. After the Clean Air Act was passed in 1970, utilities often sought to meet their standards by building very tall stacks. The EPA calculates that there are now 180 stacks more than 500 feet tall as compared to only two in 1969. Tall stacks can relieve local air pollution, but they increase acid precipitation in downwind areas. Also, because of the tall stacks, acid precipitation can be carried hundreds of miles in the atmosphere. The acidity of lakes in New York's Adirondack Mountains may be due to the acidic components of deposition originating from such distant sources as midwest coal-fired plants.

9. Acid precipitation is increasing. In the United States, in the Adirondack mountains, more than half of the remote mountain lakes at elevation greater than 2000 feet demonstrated pH values of below 5.0; of these lakes, 90 percent contained no fish. In contrast, between 1929 and 1937, only 4 percent of these lakes had a pH of under 5.0 or were devoid of fish. The mean pH of 320 lakes was 6.5 in 1930-1938. The mean pH of 216 Adirondack lakes in 1969-1975 was 4.8.

10. There is every indication that the Reagan Administration is planning to gut the Clean Air Act when it comes up for renewal or amendment in Congress. The Clean Air Act, which as written in 1970, doesn't really address the problem of acid precipitation, needs strengthening, not gutting-especially by the inclusion of measures to curtail acid precipitation. The revised law should require, among other things, the burning of low-sulfur coal, the installation of scrubbers at critical plants, investment in alternative energy sources and the establishment of emissions standards on a regional basis. The costs would be very little compared to the rate hikes imposed in recent years by OPEC. A 2% surcharge on the average utility bill in the East would get rid of half the sulfur dioxide in the region. These aren't far-out figures advanced by some wild-eyed eco-freak; they're from the report of the National Commission on Air Quality, the members of which are appointed by the President.

*The majority of the statements are direct quotes from an article in Sports Illustrated, "An American Tragedy". Sports Illustrated, September 2, 1981 by Robert H. Boyle.

Acid Precipitation Controversy

Pro Industry

"Acid precipitation includes acid: rain, snow, sleet, hail, frost, fog, mist, dew, etc... It is a problem in the United States and elswhere in the world. But the listed causes of acid rain are only hypotheses advanced by scientists to explain certain observations that they do not know how else to intepret. They are not the conclusions of experiments designed to trace acid rain from the emission sources. "* Until cause/effect can conclusively be established, stringent controls on industry would not only be presumptuous, but costly.

Your position is that since neither hard scientific evidence has been presented nor the level of control requirements stipulated, the utility industry cannot accept new EPA regulation as "truly practical." The industry will accept a "truly practical" solution if it can be shown to be cost-effective when all remedial measures, not just emission control, are considered in an objective evaluation. Whether or not you agree with this position, argue for it as strongly as you can. Use arguments that make sense and are rational. Be creative and invent new supporting arguments. Remember to learn the rationale for both your position and the environmental position. Challenge the environmental position; think of loopholes in their logic; demand facts and information to back up their arguments.

1. EPA's line of reasoning is to imply causality by association rather than by scientific proof of linkage. If the relationship between power plant emissions and acid precipitation is so overwhelming, as implied in the EPA document, the utility industry fails to understand why investigators have not been able to trace acid precipitation back to the source emissions nor provide quantitative linkage.

2. The problem is complex. Several factors other than acid precipitation are involved in ecosystem behavior. Not all observed environmental changes are attributable to acid rain alone. To blame changes on acid rain without proof is scientifically unsound and will not solve the acid rain problem.

3. The utility industry is concerned about environmental protection, but at a time when the industry is plagued with financial problems due to inflation and increased fuel costs, it cannot afford to invest large sums of money on control measures that provide no assured benefits for the environment. The industry is aware of acid rain and is funding research aimed at determining cause-effect relationships so that one can devise any necessary cost-effective remedial measures.

4. Past experience has shown that the midwestern and eastern high sulfur coal industry has been subjected to significant economic impacts when sulfur dioxide emission levels had to be reduced. At the present time, proceedings related to interstate atmospheric deposition could affect approximately 2,980 mining jobs and 191 million dollars in annual economic input, and this estimate includes only a portion of the mines that could potentially be affected. The effect on these mines will be dependent on the control scheme selected. At the present time, based on the investigations of a number of individuals, the relationship between source of emissions and effects is not well established.

5. One of the EPA's "facts" is that acid precipitation is increasing based on data collection from the past and present data. To determine the pH changes, one must recognize that the pH of lake water varies with depth and with time from year to year, from season to season within a year and from hour to hour within a day. Without considering the time and location of the measurement of pH within a waterbody, one cannot determine trends nor attach statistical significance to findings. By simply comparing two data points (one historic and one now), one cannot tell if any difference observed is within natural variability. (Daily variation can be between 1-2 pH units)

6. As far as the emission estimates go, this is one way of playing with numbers to make power plant emissions look large. In short, the total stationary combustion sources in the United States contributed approximately a 10% contribution on a global basis.

7. Nowhere in the EPA document is anything mentioned about what the emission control costs will buy in terms of environmental protection. We are not speaking of the dollar values of environmental protection. We are speaking of how much pH change will be observed in precipitation and in lake water and how many lakes will once again support fish. Perhaps this is understandable. By EPA's own admission, "there is no clear cut relationship between specific emissions and acid rain." If that is the case, it is uncertain if additional emission control on sulfur dioxide will have any effect on the acidity of precipitation.

8. If both nitrate and sulfate in the rain can be halved by some means, the precipitation pH at most changes from 4.2 to 4.5 If sulfate alone is halved, the precipitation pH may change at most from 4.2 to 4.4 This does not say that halving the power plant emissions will halve the acid concentrations in the rain. It does indicate that emission

Controls may not be very effective in changing precipitation pH values.

9. The estimates of potential damage to vegetation are based on laboratory studies where unrealistically large doses of acid were applied to the test organisms. It can be said that very little of the implied damage has been observed in the field. Damages in the nearby field of local point sources have been problems in the past. They are being brought under control by current ambient air quality standards. On farm lands and in forested areas, vegetation is still reliant upon timely rains, acidic or not. What farmers and foresters do in their normal practices will have more profound impacts on the productivity of their crops and forests than what the acidity of rain can do to vegetation.

*The majority of these statements were directly taken from a report put out by the Edison Electric Institute in response to the EPA report on acid precipitation.

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